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AIR FORCE

HUMAN RESOURCES

SIMULATOR TRAINING REQUIREMENTS AND EFFECTIVENESS STUDY (STRES): ABSTRACT BIBLIOGRAPHY

By

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Logistics Research Branch
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January 1981

Final Report

LABORATORY

AIR FORCE SYSTEMS COMMAND
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This final report was submitted by Seville Research Corporation, 400 Plaza Building, Pensacola, Florida 32505, under Contract F33615-77-C-0067, Project 1710, with the Logistics and Technical Training Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433. Mr. Bertram W. Cream was the Contract Monitor for the Laboratory.

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This technical report has been reviewed and is approved for publication.

ROSS L. MORGAN, Technical Director
Logistics and Technical Training Division

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Commander

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

abstracts	flight simulation	simulation technology	instructional support features
simulation	visual simulation	simulator evaluation	aircrew training
simulator design	motion simulation	simulator training	training technology
simulator training requirements	force simulation	aircrew training devices	adaptive training
simulator fidelity	radar simulation	performance measurement	attitudes

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents comprehensive abstracts of 196 research and development reports and other documents related to aircrew training devices (ATDs). A broad range of topics is represented: design, operation, and evaluation of simulators and simulator systems, especially visual and motion/force cueing systems; automated performance measurement; instructional support features; analysis of ATD training program requirements; ATD training methods; evaluations of ATD training; management of ATD training; costs of ATDs and ATD training; and worth of ATD ownership. These abstracts supported the overall Simulator Training Requirements and Effectiveness Study (STRES) by providing members of the research team with detailed summaries and evaluations of relevant documents. This report is one of seven prepared during STRES.

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Item 19 Continued:

training evaluation
training management
training innovations
life cycle cost
worth of ownership

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PREFACE

This report describes a portion of a study of training through simulation in the U.S. Air Force. It is one of seven technical reports prepared for the Air Force Human Resources Laboratory, Logistics and Technical Training Division, under Contract F33615-77-C-0067, Simulator Training Requirements and Effectiveness Study (STRES). The remaining six reports are identified in Chapter 1 of this document. The reports cover work performed from August 1977 through January 1980.

The work was performed by a team made up of Canyon Research Group, Inc; Seville Research Corporation; and United Airlines Flight Training Center. Canyon Research Group, Inc. was the prime contractor; Mr. Clarence A. Semple served as the Program Manager. The Seville Research Corporation effort was headed by Dr. Paul W. Caro. The United Airlines effort was headed initially by Mr. Dale L. Seay and subsequently by Mr. Kenneth E. Allbee.

Mr. Bertram W. Cream was the AFHRL/LR Program Manager. Other key members of the AFHRL/LR technical team included Dr. Gary Klein and Dr. Thomas Eggemeier. A tri-service STRES Advisory Team participated in guiding and monitoring the work performed during this contract to assure its operational relevance and utility. Organizations participating in the Advisory Team were:

- Headquarters, USAF
- Headquarters, Air Training Command
- Headquarters, Military Airlift Command
- Headquarters, Aerospace Defense Command
- Headquarters, Tactical Air Command
- Headquarters, Air Force Systems Command
- Headquarters, Strategic Air Command
- Tactical Air Warfare Center
- Air Force Manpower and Personnel Center
- Air Force Test and Evaluation Center
- USAF Aeronautical Systems Division,
- Air Force Human Resources Laboratory
- Air Force Office of Scientific Research
- Army Research Institute for the Behavioral and Social Sciences
- United States Navy Training Analysis and Evaluation Group

The authors wish to express their gratitude to the hundreds of people in the United States Air Force, Navy, Army, Coast Guard, NASA, FAA and industry who contributed to this program by participating in interviews and technical discussions during program data collection.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

THE SIMULATOR TRAINING REQUIREMENTS AND EFFECTIVENESS STUDY

Aircrew training is an expensive and time consuming endeavor. At one time or another, virtually every known training method and medium has been used to develop operationally ready aircrews and to maintain their skill levels. To meet these training needs in a cost effective manner, the U.S. military has shown increased interest in the use of simulators and other aircrew training devices (ATDs). Recent requirements to economize on aircraft fuel used for training have provided strong impetus for this interest, but other factors have contributed as well. These other factors include increasingly congested airspace, safety during training, cost of operational equipment used for training, and a desire to capitalize on training opportunities that simulators provide for skills that cannot be trained effectively, safely, or economically in the air.

Because of the advantages simulation can offer over other aircrew training media, it is current Air Force policy that ATDs be used to the fullest extent to improve readiness, operational capability, and training efficiency. Implementation of this policy requires specific technical guidance. Information upon which to base that guidance is sparse, however, and the information that does exist is not always available to those who need it. The Simulator Training Requirements and Effectiveness Study (STRES) was conceived as a means of identifying and making available the existing information related to simulator training in furtherance of relevant Air Force policies. The base of information thus assembled would provide guidance for the enhancement of present training, as well as for the focus of research and development needed to enhance future simulation-based training.

THE PRESENT REPORT

One part of the STRES effort involved preparing comprehensive abstracts of research and development reports for distribution to members of the STRES research team. This report documents the abstracting effort. The present chapter describes the overall nature of STRES. Chapter II explains the purpose of the abstracts and describes the approach for identifying documents to abstract. Chapter II also summarizes the contents of the documents abstracted and identifies the information accompanying each abstract. The abstracts comprise the third and final chapter. There are also two appendices. Appendix A is an alphabetized list of citations of the articles abstracted. Appendix B presents these citations grouped according to research topic.

STRUCTURE OF THE STRES PROGRAM

The primary objectives of STRES, as described in the contract Statement of Work for the present efforts, are to define, describe, collect, analyze and document information bearing on four key areas. These areas are:

- Criteria for matching training requirements with simulator fidelity features;
- Principles of effective and efficient utilization of simulators to accomplish specific training requirements;
- Criteria for matching simulator instructional features with specific training requirements; and
- Models of factors influencing the cost and the worth of ownership of simulation devices.

The Air Force plan for accomplishing these objectives involves a four-phase effort. Phase I, which was concluded prior to the initiation of the present study, was an Air Force planning activity that structured the total effort so that operationally meaningful simulator training issues would be addressed on a priority basis. Phase II, the effort described in the series of reports identified below, of which the present report is a part, was a 29-month study that involved collecting, integrating, and presenting currently available scientific, technical, and operational information applicable to specific aircrew training issues. Phase II also involved the identification of research and development efforts needed to enhance future simulator training. Phase II was conducted by a team composed of Canyon Research Group, Inc., Seville Research Corporation, and United Airlines Flight Training Center. Phase III is planned to be a research activity that will provide additional information on important questions related to simulation and simulator training that cannot be answered with assurance with the currently available data. Finally, building on Phases II and III, Phase IV will be an Air Force effort to integrate findings, publish relevant information, and provide for updating of the knowledge base as new information becomes available.

A tri-service STRES Advisory Team was formed to help guide STRES. The team has participated in two ways. One was to assist in the Phase I program planning. The second has been to provide guidance and evaluative feedback during Phase II to ensure that products of the phase would be operationally relevant and useful. Both operational users of ATDs and the research community were represented on the Advisory Team.

A principal task of the Advisory Team was to participate in the development of objectives and guidelines for the conduct of the Phase II

technical effort. As a focus for those efforts, a set of "high value" operational tasks was identified. The tasks selected were those for which potential ATD training benefits were judged to be greatest, and for which information on ATD design, retrofit, use, and worth was believed to be incomplete or lacking. These tasks also provided a focus for identification of questions and issues reflecting the informational needs of operational personnel that were to be addressed during Phase II efforts. The high value tasks identified by the Advisory Team are:

- Individual and formation takeoff and landing;
- Close formation flight and trail formation, both close and extended;
- Aerobatics;
- Spin, stall, and unusual attitude recognition, prevention, and recovery;
- Low level terrain following;
- Air refueling;
- Air-to-air combat, both guns and missiles; and
- Air-to-ground weapons delivery.

SOURCES OF INFORMATION

Information from two general sources was collected during Phase II to address the objectives of STRES. One source was the professional and technical literature. This literature included books, conference proceedings, professional journals, research reports, military manuals and regulations, and policy statements. The second source was the military and civilian personnel whose experiences related to the objectives of the study. Information was obtained from these personnel during visits to the organizations to which they were assigned.

Literature Review

Computer searches were made at the outset to identify literature relevant to all facets of the Phase II effort. In addition, each STRES team member identified documents pertinent to his responsibilities that may have been missed in the computer searches. In these individual efforts, articles pertinent to the various activities of other team members were regularly encountered. Each investigator was aware of the informational needs of his colleagues, and frequent communication among team members assured that colleagues would be apprised of articles of

potential value to their tasks. Hence, the search for literature of concern to the preparation of a given volume of the STRES report series, while systematically compiled by those specifically responsible for that volume, was expanded through the efforts of the entire team.

Site Visits

A considerable body of information was also obtained from organizations, both government and commercial, whose personnel are involved in the design, procurement, evaluation, management, and use of ATDs. ATD manufacturers, research and development agencies, and a commercial airline were visited in addition to Air Force, Army, Navy, and Coast Guard military training sites. At each organization, extensive data were obtained through observations, interviews, and document reviews.

Specific objectives of the interviews and other data collection efforts varied, depending on the type of organization visited and the purpose of the visit. Manufacturers and research and development agencies were visited to assess current and projected technology and to review ongoing and planned efforts bearing on STRES program objectives. ATD using organizations were visited to obtain a variety of information related to types and effectiveness of training accomplished, uses of various types of devices in accomplishing the training, ATD design characteristics, worth of ATD ownership, and ATD life cycle costs.

STRES PHASE II REPORTS

Seven reports were prepared to document Phase II efforts and findings:

Spears, W.D., Sheppard, H.J., Roush, M.D., & Richetti, C.L. *Simulator Training Requirements and Effectiveness Study (STRES): Abstract Bibliography.* AFHRL-TR-80-38. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Caro, P.W., Shelnutt, J.B., & Spears, W.D. *Aircrew Training Devices: Utilization.* AFHRL-TR-80-35. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A., Hennessy, R.T., Sanders, M.S., Cross, B.K., Beith, B.H., & McCauley, M.E. *Aircrew Training Devices: Fidelity Features.* AFHRL-TR-80-36. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A., Cotton, J.C., & Sullivan, D.J. Aircrew Training Devices: Instructional Support Features. AFHRL-TR-80-58. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Allbee, K.E., & Semple, C.A. Aircrew Training Devices: Life Cycle Cost and Worth of Ownership. AFHRL-TR-80-34. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Prophet, W.W., Shelnutt, J.B., & Spears, W.D. Simulator Training Requirements and Effectiveness Study (STRES): Future Research Plans. AFHRL-TR-80-37. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A. Simulator Training Requirements and Effectiveness Study (STRES): Executive Summary. AFHRL-TR-80-63. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

CHAPTER II

THE COMPREHENSIVE ABSTRACTS

PURPOSE

The purpose of the abstracts was twofold. First, they were to be the beginning of a computerized data base. Second, they were to support the overall STRES II effort by providing comprehensive summaries of research reports and other documents relevant to the project, and assessments of the merits of individual research reports. Accordingly, abstracts were prepared on a continuing basis throughout Phase II. They were distributed to members of the STRES project team monthly. In addition, informal evaluations of some reports were distributed even though the reports themselves were not abstracted. In these cases, the evaluations were to alert team members to the lack of relevance of the reports, or to debilitating methodological errors that rendered meaningful interpretations of data impossible.

APPROACH

The identification of literature to be abstracted followed the development of the Phase II effort. In the beginning, information was needed regarding the state-of-the-art technology of ATD design and training, and Air Force Human Resources Laboratory (AFHRL) provided approximately 300 technical reports and other documents of this nature at the outset. In addition, early computer searches identified numerous other articles of potential value. The preparation and dissemination of abstracts thus began very soon after the project was initiated. At this stage, the focus was upon documents concerned with engineering aspects of ATDs published between 1970 and 1977. Reports on ATD training were not emphasized because of the availability of comprehensive abstracts in this area from the extensive AFHRL Automated Data on Instructional Technology (ADIT) Information System. As the Phase II effort progressed, it became apparent that ATD capabilities and their relation to aircrew training effectiveness were a principal concern, so abstracts were prepared for increasing numbers of reports that dealt with ATD capabilities and their effects on ATD training and performance. Fidelity issues in general were a concern, and visual and motion cueing received special attention. In the later stages of the Phase II effort, the focus shifted more and more to documents published after Phase II began. Reports on ATD training were then abstracted more often so as to remain current with emerging practices. The major portion of abstracts dealing with cost and cost effectiveness analyses were also prepared during the later stages of the project.

In all, some 1100 articles were identified as possibly relevant to the STRES study. Examinations of authors' abstracts revealed approximately half merited closer study. The latter group were then examined by various members of the project team who identified candidates for abstracting. It was not possible to abstract all worthy reports that were identified, however, so selections were made according to the evolving needs for information just discussed. Fortunately, the ADIT file contained comprehensive abstracts for many useful articles, so abstracting efforts could focus on those not included in the ADIT file. Also, in a number of instances, particular reports were selected for abstracting because they included or updated information available in other reports, making abstracts of the latter unnecessary for immediate purposes.

A total of 196 abstracts were prepared and appear as Chapter III of this report. Their inclusion here provides the reader of the STRES reports with in-depth discussions and evaluations of much of the research that figured significantly in the preparation of the STRES reports.

CONTENTS OF DOCUMENTS ABSTRACTED

As stated, the availability of abstracts of training research in the ADIT file led to an uneven emphasis on types of content of documents abstracted during STRES. Sixty percent of the abstracts are for articles dealing with simulation technology, including simulator design; simulation procedures and techniques; definition of ATD training requirements; and evaluations of ATD capabilities through engineering analyses and effects on aircrew performance and training.

Table 1 shows percents of abstracts addressing major aspects of ATD design and utilization. With only two exceptions, an abstract was classed under only one head. These exceptions examined joint effects of visual and motion/force cueing. The category Simulators/Subsystems (27%) includes reports that examined entire simulator systems, or one or more subsystems (hardware, software, instrumentation, etc.). However, articles addressing only visual or motion/force systems are classified separately under Visual Cueing (13%) or Motion/Force Cueing (13%). All three of these categories have subheads, Design Considerations and Operation/Evaluation. Design Considerations include analytic and empirical studies that sought to clarify design requirements or technical alternatives. Operation/Evaluation includes articles describing how systems and subsystems function, and analytic and empirical evaluations of adequacy or usefulness of operational features. A fourth category, Miscellaneous ATD Capabilities (7%), includes reports on performance measurement, instructional support features, radar simulation, and provisions for adaptive training.

Reports classified under ATD Training (16%) are of two types. Analysis/Development includes those concerned with determining training content and developing training regimens that have implications for ATD utilization. Principles/Methods include analytic and empirical studies addressing desirable training practices or evaluations of alternative training methods.

TABLE 1. PERCENTS OF ABSTRACTS BY MAJOR TOPICS

Category		Percent of total
Simulators/subsystems		27
Design considerations	11	
Operation/evaluation	16	
Visual cueing		13
Design considerations	7	
Operation/evaluation	6	
Motion/force cueing		13
Design considerations	5	
Operation/evaluation	8	
Misc. ATD capabilities		7
ATD Training		16
Analysis/development	7	
Methods/principles	9	
Cost/worth		17
Management		8
		101[a]

[a]Percents add to a total of 101 rather than 100 because two reports were classified under two heads.

Cost/Worth (17%) includes docum[illegible]ts describing or illustrating procedures for analyses of ATD cost an[illegible] [illegible]ost effectiveness, and for determining "worth of ownership" of AT[illegible]. While life cycle cost was a primary concern for STRES, articles [illegible]ostracted also include those that

address any part of life cycle costs of ATDs--cost of design and development, procurement, operation, training, and support, as well as disposal when no longer usable. "Worth of ownership" is a subjective concept. It is concerned with factors that govern judgments as to the relative value of devices for accomplishing objectives. Articles of this type that were abstracted addressed how to quantify the judgmental factors.

The last category, Management (8%), includes articles whose major purposes concern overall aspects of ATD utilization--program evaluations, utilization handbooks, user attitude management, and effecting changes in training equipment and programs.

INFORMATION ACCOMPANYING ABSTRACTS

Each abstract includes a complete citation to the original document and a statement of its purpose. Where applicable, the abstract proper provides a description of the approach used in the study, a summary of the findings, and the author's conclusions and research suggestions. For a highly detailed document such as a handbook, procedural guide, etc., for which a detailed abstract is not feasible, the intended user groups are identified and the major thrusts of the document explained. Except for Department of Defense Instructions, an evaluation accompanies each abstract that identifies any major weaknesses in the study, as well as major strengths if they are not readily apparent from the abstract itself and a general evaluative statement.

A number of other items of information are listed separately from the body of the abstract proper. These items, termed segments, are discussed below.

Segments Appearing in Abstracts

A total of 34 different segments were used in the abstracts. In most cases these segments are the same as appear in the ADIT file, but in a few instances segments had to be adapted for STRES because of differences in ADIT and STRES purposes and types of documents abstracted. Only 18 segments always appear in every abstract. The remainder appear only as they are applicable. The numbers, names, and descriptions of the segments follow. Many numbers are omitted in the sequence to allow for future insertion of additional segments. Asterisks appear beside those numbers that appear in all abstracts, whether or not information regarding the segment was available.

*1. Accession Number: These numbers are assigned for the AFHRL technical reports available from the Defense Technical Information Center.

*4. Citation: autnor(s), report title, source or publisher, publisher's location, report number (if any), and publication date.

*5. Abstract: the body of the abstract proper. Appearing separately are a statement of purpose and, as applicable, either a general summary or a description of the empirical method and results.

6. Author's Conclusions: substantive conclusions drawn by the author(s) that are not readily apparent in the abstract.

*7. Evaluation: a general statement regarding the merits of the report. Serious shortcomings are identified specifically, and their impacts on results and author's conclusions are explained.

8. Comments: any special or qualifying observations made by the abstractor that cannot readily be included in other segments.

10. Author's Research Suggestions: specific but not general suggestions for further research made by the author(s).

12. Cross-References: separate report(s) containing information required to interpret the one abstracted.

14. Dependent Variables: the measures of the dependent or criterion variables in experimental studies; also, when applicable, the variable to be affected (e.g., optimized) by variables or conditions treated in analytic studies.

15. Independent Variables: factors, conditions, etc., whose effects are the subject of study.

16. Measurement/Statistical Methods: formal measuring instruments used, and statistical techniques other than common summary statistics (means, proportions, etc.).

18. Special Analytic Techniques: new techniques employed, or innovative uses of standard techniques.

20. Apparatus/Media Used: equipment used for training in empirical studies, except for ATDs and equipment closely related to them.

22. System/Class: general type/special instance of ATD or ATD-related equipment at issue.

23. Subject Pool: the characteristics of the "population" from which experimental subjects were drawn. However, only subjects whose behavioral changes comprised dependent variables are identified. Personnel used, for example, to "fly" an ATD for tweaking are not subjects in this sense, they are part of the measuring apparatus.

*24. Number of Pages: total number of pages in report, including tables of contents, appendices, etc., but excluding report distribution lists. (This number often is different from that appearing on documentation pages of technical reports because of inconsistencies in pagination from report to report.)

*25. Number of References: the total number of references cited in the report.

*28. Research Class, and *29. Research Method: principal characteristics of the research as reported. Many reports could be classified under more than one pair of heads, but decisions were made according to dominant characteristics. In cases where clear-cut classifications were not otherwise possible, the thrusts of the abstracts pertinent to purposes of STRES were the deciding factors. Research Classes and subordinate Research Methods were as follows:

STATUS STUDY: Description; Description/evaluative; Structural analysis; Survey/descriptive; Survey/evaluative; Normative; Historical.

LOGICAL STUDY: Logical analysis and description; Organization; Deductive reasoning; Mathematical derivation; Argument/dialectics; Theory development; Critique.

EXPERIMENTAL ANALYSIS: Informal experiment; Ex-post-facto comparisons; Formal experiment/single variable; Formal experiment/multiple variable.

32. Descriptive Notes: as appear on the documentation page of technical reports if any are given.

33. Supplementary Notes: as appear on the documentation page of technical reports if any are given.

*36. Report Title: as in Citation, Segment 4.

*37. Report Author: as in Citation, Segment 4, for single or multiple authors.

*38. Report Date: date of publication of report abstracted; may be different for draft and final publications. When dates on report cover and documentation page differed, the latter was used.

*40. Originating Activity: organization responsible for performing the study and/or preparing the report.

44. Contract/Project/Task: contract, project, and task numbers when provided with the report.

48. Report Number: the number, if any, appearing on government technical reports.

49. Other Report Number: the originator's or performing organization's number, if any.

*52. Publisher/Sponsor: the organization that published the copy of the report abstracted; if different from a government sponsoring agency, the sponsor is identified as well.

*56. Type of Publication: the descriptor given on documentation pages of government sponsored research reports (technical report, research memorandum, etc.); Department of Defense Directives, journal articles, expository articles, chapters in books, etc., are identified as such.

*60. Distribution Statement: nature of distribution statement (unlimited, government agencies only, no foreign release) when one appears on a government report.

*64. Location Symbol: not completed for any abstract. This information will be supplied at a later time.

*65. Location File: not completed for any abstract. This information will be supplied at a later time.

*66. Last Date of Update: not completed for any abstract. This information will be supplied at a later time.

CHAPTER III

ABSTRACT BIBLIOGRAPHY

Abstracts for 196 documents appear in the sequence in which they were abstracted. As explained, bases for selecting documents evolved as Phase II of STRES progressed, so topics do not appear in any particular order. However, the reader may locate abstracts of particular interest by consulting Appendices A and B. Appendix A lists all citations in the alphabetical order of the senior or sole author's last name. Appendix B is also an alphabetical listing, except that abstracts are grouped according to the topics identified in Table 1.

Pagination, which begins anew with each abstract, identifies the number of the abstract and the number of the abstract page as it appears in sequence. For example, Abstract No. 051 has pages 051-1, 051-2, 051-3, etc. Abstract No. 052 begins with page 052-1, etc.

APPENDIX

ALPHABETIZED LIST OF CITATIONS

Abstract Number

Adams, J.A.; Hufford, L.E. Contributions of a Part-Task Trainer to the Learning and Relearning of a Time-Shared Flight Maneuver. HUMAN FACTORS, 4, 159-170, 1962. — 024

Air Force Systems Command. Cost Analysis: Cost Estimating Procedures. Headquarters Air Force Systems Command, Andrews Air Force Base, D.C., AFSCM 173-1, 17 April, 1972. — 174

Albers, F.G. Microcomputer Base for Control Loading. ELEVENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 109-112, 14-16 November, 1978. — 130

Albery, W.B.; Gum, D.R.; Kron G.J. Motion and Force Cueing Requirements and Techniques for Advanced Tactical Aircraft Simulation. AGARD MEETING ON PILOTED AIRCRAFT ENVIRONMENT SIMULATION TECHNIQUES, April, 1978. — 149

Air Force. Cost of Ownership Handbook. Air Force Test and Evaluation Center, Kirtland Air Force Base, New Mexico, May, 1976. — 176

Air Force. Guide to Analysis of Contractor Cost Data. Headquarters Air Force Systems Command, Andrews Air Force Base, D.C., 1 June, 1977. — 175

Air Force. Logistic Support Cost Impact. (Attachment 1, apparently to Request for Proposal F33657-76-A-0648). — 181

Air Force. Logistic Support Cost Model: User's Handbook. U.S. Air Force, August, 1976. — 171

Ashworth, B.R. A Seat Cushion to Provide Realistic Acceleration Cues for Aircraft Simulators. National Aeronautics and Space Administration, Langley Research Center, Hampton, Virginia, NASA TM X-73954, September, 1976. — 156

Ashworth, B.R.; McKissick, B.T. The Effect of Helmet Loader G-Cueing on Pilot's Simulator Performance. AIAA FLIGHT SIMULATION TECHNOLOGIES CONFERENCE, 15-20, 18-20 September, 1978. — 155

	Abstract Number
Ashworth, B.R.; McKissick, B.T.; Martin, D.J., Jr. Objective and Subjective Evaluation of the Effects of a G-Seat on Pilot/Simulator Performance During a Tracking Task. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 61-79, 15-17 November 1977.	016
Askren, W.B.; Korkan, K.D. Design Option Tree: A method for Systematic Analysis of Design Problems and Integration of Human Factors Data. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-75-9, July, 1975.	001
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APPENDIX B

ALPHABETIZED LISTS OF CITATIONS BY RESEARCH TOPIC

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ABSTRACT 001
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Key Number

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5 ABSTRACT:
PURPOSE: The purpose of the study was to formulate a method for systematic analysis of design problems using human factors data as decision criteria.
SUMMARY: The Design Option Decision Tree (DODT) was developed as a means of anticipating and identifying the trade-offs in weapons systems design so that human resources data may be used as decision criteria. The DODT depicts graphically the sequence of engineering decisions required for resolution of a design problem. DODTs for an automobile and two diverse aircraft design problems were discussed to show the universality of application of the DODT. The following steps were proposed to construct a DODT: (a) perform a literature survey; (b) conduct in-house interviews with engineers and update; and (c) interview outside experts and update. Three tasks in developing a DODT were: (a) determine the branches of the Tree; (b) decide whether a junction is a decision or routing point; and (c) identify options available at decision points. Within the DODT, a numerical evaluation scheme can be established by assigning a scale rating to each of the design parameters of interest, permitting a quantitative determination of the best path through the Tree. To account for the possibility of new technology areas, a confidence level for the feasibility of engineering development can be assigned to each option in the Tree, in addition to the scale rating. The confidence level would be expressed as a per cent probability that a new area will be developed in a stated number of years. Previous research suggests that many decision points in a DODT will impact the human factor elements of the system, the elements varying with the kind of decision to be made. Also, human factors data can be integrated by generating human factors effects data for each design option and translating the data into quantitative units for incorporation into mathematical analyses of the design option.

Key Number

6 AUTHOR'S CONCLUSIONS:
The DODT meets the goal of devising a method to analyze design problems and to integrate human factors into engineering decisions. In addition, it appears useful: (a) as an engineering management tool; (b) as a measure of state-of-the-art uniqueness of the final design product; (c) in redesign efforts; (d) in indoctrinating new employees regarding a system development program; and (e) in developing the thesis that engineering design is a human decision-making process.

7 EVALUATION:
The concepts of the DODT are clearly explained. While the thrust of the article concerns designs of weapon systems, the material is generalizable and can be relevant to use of human factors data in simulator design. Conclusions are overdrawn, however. Tryouts are needed to test uses and applications identified in conclusions.

22 SYSTEMS/CLASS:
Weapons Systems

24 NUMBER OF PAGES:
0019

25 NUMBER OF REFERENCES:
0004

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Analysis/description

33 SUPPLEMENTARY NOTES:
Professional paper presented at the 18th Annual Meeting, Human Factors Society, Huntsville, Alabama, 15-17 October 1974. Supported by Systems Research Laboratories under Contract F33615-73-C-4044, 17100723, Operation of Instructional Systems Research Facility, using results of a study by SFL under Contract F33615-70-C-1440, 17100719, Characteristics of Effective Training and Training Equipment.

36 REPORT TITLE:
Design Option Tree: A Method for Systematic Analysis of Design Problems and Integration of Human Factors Data

37 REPORT AUTHOR:
Askren, W.B.; Korkan, K.D.

Key Number

38 REPORT DATE:
75/07/00

40 ORIGINATING ACTIVITY:
Advanced Systems Division, Wright-Patterson Air Force Base, Ohio; and Systems Research Laboratories, Inc., Dayton, Ohio

44 CONTRACT/PROJECT/TASK:
62703F/11240103

48 REPORT NUMBER:
AFHRL-TR-75-9

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 002
15 November 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Mendela, D.K. Recent Experiences with a Fixed Base Simulator in the Investigation of Handling and Performance Problems of the V.T.O.L. Transport Aircraft. AIAA VISUAL AND MOTION SIMULATION TECHNOLOGY CONFERENCE PROCEEDINGS, Cape Canaveral, Florida, 16-18 March, 1970.

5 ABSTRACT:

PURPOSE: The purpose of the study was to explore the use of a fixed-base simulator in the investigation of handling and performance problems of a vertical takeoff and landing (VTOL) transport aircraft.

METHOD: An unstated number of test pilots with current VTOL aircraft and helicopter experience participated in simulated VTOL flights, using typical flight profiles for inter-city operation. The fixed-base simulator's flight deck was equipped with conventional jet airliner dual controls, adapted for VTOL requirements. A realistic instrument panel was incorporated in the simulator, together with a "reasonably realistic" head-up visual display and a motion system. A 400-amplifier analogue computer was used to solve equations of motion in six degrees of freedom; to simulate four lift fan units; to penetrate visual displays; to control the electro-hydraulic fuel unit; and to perform Euler angles and axes transformations. An unstated number of flights were conducted varying (a) altitude demand autostabilization system in roll and pitch; (b) rate demand system in yaw; (c) thrust-to-weight ratio; (d) turbulence conditions; (e) single and double lift fan engine failure; and (f) control break-out forces and travel. Principal dependent measures ascertained pilots' (a) ability to hover; (b) rates of climb and descent; (c) height controllability; (d) landing accuracy; (e) forward speed.

RESULTS: (a) Sudden switching off of the autostabilizer resulted in large disturbances, while gradual phasing out of this system did not; (b) sideways positioning maneuvers were more difficult by banking than by using side acceleration control; (c) vertical descents as low as 50 ft/min were repeatedly achieved; (d) pilots generally preferred left-hand control of lift and propulsion engines, right-hand access to the control column, and the helicopter type of control column rather than the wheel; (e) single lift fan engine failures were usually detected after two seconds; (f) cross-wind effects on

Key Number

aircraft handling were marked; (g) range of visual display (+11 degrees and -17.5 degrees in elevation, $\pm$ 18 degrees in azimuth) was inadequate in some yawing maneuvers; (h) absence of cockpit motion made simulator turbulence conditions unrealistic; (i) hover and positioning maneuvers prior to touchdown were not problems with the autostabilization system as simulated; (j) conventional cruise flight at less than minimum drag speed was speed-unstable without autothrottle; (k) attempts to share flying tasks between 1st and 2nd pilots were unsuccessful.

6 AUTHOR'S CONCLUSIONS:
(a) Head-up and head-down displays are needed on the proposed VTOL to assist the pilot, particularly in landing accuracy, but they should provide a wider angle of view than the one used in this study; (b) fixed based simulator results are valid for aircraft with good handling characteristics, but lack of motion degrades marginally acceptable aircraft control characteristics; (d) engine and aero-dynamic noise added to the realism of VTOL simulation; (d) a reliable power operated control system fuel unit in the simulator is essential; and (d) the simulator was valuable for determining desirable cockpit control arrangements experimentally.

7 EVALUATION:
This article is informative but interpretations of results are uncertain because: (a) the Methods section described primarily the capabilities of the simulator, omitting experimental procedures (e.g., number of flights, nature of missions, data collection and reduction methods); (b) number and characteristics of pilots used to obtain data were not stated other than that they were experienced VTOL pilots; (c) figures were presented with no explanation of sources of data or how or why they supported conclusions drawn from them; and (d) only "typical" results were presented, i.e., variances within sets of measures were not presented.

14 DEPENDENT VARIABLES:
Rate of climb; rate of descent; landing accuracy; maintenance of forward speed; hoverability; height controllability

15 INDEPENDENT VARIABLES:
Attitude demand autostabilization system in roll and pitch; rate demand system in yaw; thrust-to-weight ratio with interference lift thrust losses; wind direction and turbulence; single and double lift fan engine failures; control break-out forces; control travel

Key Number

22 SYSTEM/CLASS:
Vertical takeoff and landing simulator

24 NUMBER OF PAGES:
0011

25 NUMBER OF REFERENCES:
0009

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Recent Experiences with a Fixed Base Simulator in the Investigation of Handling and Performance Problems of the V.T.O.L. Transport Aircraft

37 REPORT AUTHOR:
Mendela, D.K.

38 REPORT DATE:
70/03/00

40 ORIGINATING ACTIVITY:
Hawker Siddeley Aviation Limited, Hatfield, Hertfordshire, England

49 OTHER REPORT NUMBER:
AIAA Paper No. 70-345

52 PUBLISHER/SPONSOR:
American Institute of Aeronautics and Astronautics, New York, N.Y.

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 003
15 November 1977

Key Number

1 ACCESSION NUMBER: AD-A040 550

4 CITATION:

Cyrus, M.L.; Templeton, T.K. Buffet Simulation for Advanced Simulator for Pilot Training (ASPT). Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-77-4, March, 1977.

5 ABSTRACT:

PURPOSE: The purpose of the study was to develop relatively simple mathematical models representing realistic buffet effects in the Advanced Simulator for Pilot Training (ASPT).
SUMMARY: A mathematical model for the motion system of the ASPT included Link simulation of the following effects: (a) speed brake buffet; (b) runway rumble; (c) landing gear down buffet; (d) landing gear in transit vibration; (e) landing gear down lock; (f) aerodynamic (stall) buffet; (G) touchdown bump; and (h) aerodynamic (rough air) buffet. A subjective analysis of cues required in the ASPT for realistic simulation of buffets in the aircraft was made from detailed information provided by two AFHRL/FT-37 research instructor pilots regarding (a) through (h) above. The pilots also provided information regarding frequency and magnitude cues, and direction and onset characteristics of buffets. The information provided by the two pilots was "virtually identical" for both the Link effects and cue structure. Analyses of this information revealed that simple linear equations could provide adequate models for six of the buffeting effects. With A representing a constant that varies in magnitude with each equation, R a uniformly distributed random number, F a force directed toward the center of the earth, V the airspeed, and W the vertical velocity of the aircraft at touchdown, the buffet effect B may be stated as follows: runway rumble, B=AF; landing gear down buffet, B=ARV, landing gear in transit vibration, B=ARV; landing gear down lock, B=A; touchdown bump, B=AW. Rough air buffets are integrated into the Link system and their effects are represented by three independent equations of the form B=AR, with one equation representing each of the three dimensions of space. More complex mathematical models were required for speed brake buffet which varied jointly with airspeed and degree to which speed brakes were open, and for stall buffet for which a tentative formulation (with undefined quantities) was unsatisfactory to the authors.

Key Number

7 EVALUATION:
The equations for buffet effects were deduced from subjective analyses of buffeting conditions and their "validation" rested upon subjective impressions of adequacy. However, no information was provided regarding details of the subjective analyses or validation procedures. The equations are intuitively reasonable provided constants A are adjusted to reflect dimensional homogeneity for all buffets. Also, one might expect harmonic effects that cannot be duplicated by random numbers. The goal, however, was the establishment of simple models, and the equations deduced merit empirical test.

14 DEPENDENT VARIABLES:
Subjective realism of buffet simulation arising from: (a) runway rumble; (b) landing gear down buffet: (c) landing gear in transit vibration; (d) landing gear down lock; (e) touchdown bump; (f) speed brake buffet; (g) stall effect; and (h) rough air buffet.

15 INDEPENDENT VARIABLES:
(a) Airspeed; (b) force directed toward earth's center; (c) vertical velocity at touchdown; (d) degree speed brakes are open; and (e) angle of attack.

22 SYSTEM/CLASS:
Advanced Simulator for Pilot Training/buffet simulation

24 NUMBER OF PAGES:
0009

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Deductive reasoning

36 REPORT TITLE:
Buffet Simulation for Advanced Simulator for Pilot Training (ASPT)

37 REPORT AUTHOR:
Cyrus, M.L.; Templeton, R.K.

38 REPORT DATE:
77/03/00

Key Number

40 ORIGINATING ACTIVITY:
Flying Training Division, Air Force Human Resources Laboratory,
Williams Air Force Base, Arizona

44 CONTRACT/PROJECT/TASK:
62703F/11230301

48 REPORT NUMBER:
AFHRL-TR-77-4

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 004
15 November 1977

Key Number

1 ACCESSION NUMBER: AD-A017 165

4 CITATION:
Faconti, V.; Epps, R. Advanced Simulation in Undergraduate Pilot Training: Automatic Instructional System. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-75-59(4), October, 1975.

5 ABSTRACT:
PURPOSE: The purpose of the study was to describe the automated instructional system (AIS) of the Advanced Simulator for Undergraduate Pilot Training (ASUPT).
SUMMARY: The ASUPT system is a research device for investigating simulation in undergraduate pilot training. Four major components of its AIS are: (a) an alphanumeric cathode ray tube (CRT) which provides five separate display channels and is used to display digital information; (b) a calligraphic CRT which presents graphical information; (c) an addressable reel-to-reel audio tape recorder which, during replay of a recorded flight, provides a narrative to the student and instructions as to what should be monitored and observed; and (d) a random access audio memory drum which together with a computer constructs verbal messages and transmits them to the student. The alphanumeric display system programs can: generate alphanumeric pages on-line in the nonreal time foreground environment; plot simulator/student variables; provide real time data sampling and display of ASUPT data pool variables; and provide record/playback of training exercises. The graphic display system provides cross-country, ground controlled approach, formation flying, spatial, and text translation displays. Descriptions of these displays and means for their control are presented. Automated instructional features include: (a) malfunction insertion, manual or automatic as a function of simulator state variables; (b) variation of task difficulty through controlling flight simulation fidelity, motion system response, environmental conditions, and the frequency and number of malfunctions; (c) performance feedback provided via auditory and visual channels; (d) demonstration and replay of standardized pre-recorded demonstrations of flight maneuvers and of student performance; (e) performance data recording through several possible output devices; (f) instructor feedback having both digital and graphic representations of performance data; and (g) maneuver sequencing, both manual and automatic. A procedures monitoring system is

Key Number

designed to give the instructor an indication of the trainee's actions during important events. Automatic maneuver sequencing allows experimentation in lock-step vs. adaptive task sequencing and performance measurements.

7 EVALUATION:
This report was written clearly and provided useful illustrations of the capabilities of the AIS. The AIS provides numerous possibilities for research in the use of the instructional features described.

8 COMMENTS:
This report is the fourth of seven volumes describing the ASUPT development program. All seven appear as AFHRL-TR-75-59 reports.

22 SYSTEM/CLASS:
Flight simulator/Advanced Simulator for Undergraduate Pilot Training (ASPT)

24 NUMBER OF PAGES:
0065

25 NUMBER OF REFERENCES:
0002

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

33 SUPPLEMENTARY NOTES:
The report was prepared in cooperation with AFHRL personnel and based on AFHRL TR-69-29, Automated Instruction and Performance Monitoring in Flight Simulation.

36 REPORT TITLE:
Advanced Simulation in Undergraduate Pilot Training: Automatic Instructional System

37 REPORT AUTHOR:
Faconti, V.; Epps, R.

38 REPORT DATE:
75/10/00

40 ORIGINATING ACTIVITY:
Singer-Simulation Products Division, Binghamton, New York

Key Number

44 CONTRACT/PROJECT/TASK:
63102F/11920101

48 REPORT NUMBER:
AFHRL-TR-75-59(4)

49 OTHER NUMBER:
Singer, ASUPT 80

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 005
15 November 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Hutton, D.P.; Burke, D.K.; Englehart, J.D.; Wilson, J.M., Jr.; Romaglia, F.J.; Schneider, A.J. Air-to-Ground Visual Simulation Demonstration, Parts 1 and 2. Aeronautical Systems Divisions, Wright-Patterson Air Force Base, Ohio, Final Report, P.E. 64227F, October, 1976.

5 ABSTRACT:
PURPOSE: The purpose was to evaluate the technical feasibility of air-to-ground visual simulation as demonstrated by existing technologies.
SUMMARY: This document is in two parts. Part 1 reports results of technical and operational evaluations of four air-to-ground visual simulation systems. Part 2 catalogues the data and data gathering procedures upon which the evaluations are based. Three systems were modified to an extent deemed necessary for the evaluation, although because the evaluations were not to be comparative, no attempts at standardization of modifications were made. The first system was the Advanced Simulator for Undergraduate Pilot Training (ASUPT) for which special algorithm development and implementation programs were designed to generate weapons trajectories, ordnance effects, moving model paths, and weapons delivery scoring. A special environmental data base was also designed and an optical gun-sight installed. A second system, the Large Amplitude Multi-Mode Aerospace Research Simulator (LAMARS), was augmented by a state-of-the-art helmet-mounted sight system that permitted the optical probe and camera to be slaved to the pilot's head and to the aircraft. Also the visual scene was fixed to a specific point or target on the terrain model board. A third system, the Simulator for Air-to-Air Combat (SAAC/F-4E No. 18 Simulator) was modified by adapting the model board to include 3-dimensional models of conventional gunnery ranges and a photomosaic airfield/industrial complex. Dynamic control of the area of interest (AOI) was target fixed and the optical probe was slaved to focus continuously on the target. The fourth device, the 2B35 simulator, was included so that effects of its specific capabilities (e.g., color) could be compared to those of other systems lacking one or more such capabilities. Technical evaluations of each system involved a series of instrumented tests designed to measure its static and dynamic capabiities. Tests used were those considered most appropriate

Key Number

for each individual system. Operational evaluations were made from mission recordings of pilots' comments, and from questionnaires completed by them, regarding conformity of simulations to real-world performance. Data for operational evaluations were acquired from six fighter pilots flying approximately 10 sorties of varying task complexity in each device. Findings from the technical and operational evaluations of ASUPT, LAMARS, and SAAC were discussed as they applied to 10 features of visual systems: (a) Field of view (FOV): all systems can provide a large FOV at low risk; (b) Area of Detailed Imagery: ASUPT can readily generate and display full FOV imagery, LAMARS may provide a sufficient AOI but at medium risk, and SAAC is not viable; (c) AOI Control: all systems were adequate with low to medium risk; (d) Image Characteristics: color is a low risk feature for LAMARS, but addition of color to ASUPT and SAAC is high risk; (e) AOI Background Characteristics: AOI background is not required for ASUPT, and featureless backgrounds can be added to LAMARS and SAAC with low risk; (f) Moving Models: generation of moving models is low risk for ASUPT and LAMARS, and low to medium for SAAC; (g) Gaming Area: large and multiple gaming areas are low risk for all systems, although cost could be a negative factor for SAAC; (h) Flight Maneuvering: ASUPT and LAMARS have no vertical and almost no horizontal travel restrictions, and at medium risk a horizontal restriction in the SAAC due to optical probe head size could be overcome; (i) Special Effects: weapons impact and scoring are low risk for ASUPT and LAMARS and medium risk for SAAC, while provisions of visibility restrictions and day/dusk/night and cultural lighting are low risk for all three, and generation and display of ceiling conditions are low to medium risk for all three; (j) Air-to-Ground Missile, SAM, Flak, and Tracer Fire: simulation of effects are low risk in ASUPT as are image generation of them for SAAC, and displays for SAAC and LAMARS if a large dome is used for the latter. A hypothetical system was described which could capitalize on many, but not all, of the successful features of ASUPT, LAMARS, and SAAC.

6 AUTHOR'S CONCLUSIONS:

(a) "Visual air-to-ground weapons delivery simulation was demonstrated with (state-of-the-art) technologies;" (b) "a system utilizing (computer image generation) of an optical mosaic provided satisfactory visual cues, had a sufficient FOV, and possessed the flexibility essential for air-to-ground task accomplishment"; (c) "A system utilizing (TBM/Dome Projection) has marginal operational utility for air-to-ground weaponry task performance"; (d) "TMB/Optical Mosaic system technologies should not be pursued for application to the air-to-ground role"; and (e) the hypothetical system developed could "potentially allow the performance of air-to-ground delivery

Key Number

tasks"; but cannot at this time "be considered a near term solution . . . due primarily to the lack of a sufficiently large AOI capability."

7 EVALUATION:

This report contains a considerable volume of valuable information regarding state-of-the-art, air-to-ground visual simulation. It is useful as a source of data and procedures as well as for the analyses and conclusions reported. Some inconvenience in reading is entailed by descriptions of procedures and data appearing in Part 2, separated from the main narrative in Part 1. However, the volume of information reported made such a separation necessary to avoid confusion of data, procedures, and summary results. The authors did an excellent job of dividing the material while at the same time providing sufficient continuity and detail to render the main narrative clear and concise.

10 AUTHOR'S RESEARCH SUGGESTIONS:

Two suggestions for further research and development were made in the form of recommendations: (a) initiate a program to provide a cost effective computer image generated (CIG)/Optical Mosaic System with expanded capabilities; (b) initiate an evaluation of the engineering feasibility of developing a prototype CIG/Dome Projection System with enriched ground environment throughout the field of view.

14 DEPENDENT VARIABLES:

Adequacy of visual systems accompanying air-to-ground weapons delivery simulation for: field of view; area of interest control; detailed imagery; image characteristics; background; moving models; gaming area; weapons fire; flight maneuvering; light and ceiling conditions

22 SYSTEM/CLASS:

Air-to-ground weapons delivery visual simulation

24 NUMBER OF PAGES:

0361

25 NUMBER OF REFERENCES:

0009

28 RESEARCH CLASS:

Status Study

29 RESEARCH METHOD:

Survey/evaluative

Key Number

36 REPORT TITLE:
Air-to-Ground Visual Simulation Demonstration

37 REPORT AUTHOR:
Hutton, D.P.; Burke, D.K.; Englehart, J.D.; Wilson, J.M., Jr.; Romaglia, F.J.; Schneider, A.J.

38 REPORT DATE:
7'/10/00

40 ORIGINATING ACTIVITY:
Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio

44 CONTRACT/PROJECT/TASK:
P.E. 64227F/Project No. 2235

52 PUBLISHER/SPONSOR:
Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio

56 TYPE OF PUBLICATION:
Final report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

64 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 006
19 November 1979

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Ricard, G. L.; Norman, D. A.; Collyer, S. C. Compensating for Flight Simulator CGI System Delays. NINTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 131-138, 9-11 November, 1976.

5 ABSTRACT:

PURPOSE: Iterations of the visual system dynamics require that a system state X(N) be extrapolated to predict the next state X(N plus 1). Delays in representing the predicted state are due to the time required to calculate predictions and process them for display. If too long the system appears sluggish; if too short, i. e., if rate of change is too high, the display jitters. The purpose of this research was to evaluate a linear, and therefore relatively rapid prediction together with a first-order low-pass filter to reduce high frequency distortion.

METHOD: The experiment was run in three stages. In Stage 1, five experienced pilots flew a control task (straight and level flight in mild turbulence) with a simulator configured as a general aviation, light, twin-engine aircraft, and when configured as a high performance aircraft. For each simulation, Ss experienced varying delays in a visual display. Three dependent measures were obtained, roll error in degrees, stick deflection in inches, and relative crossover power. Four of the same subjects were used under similar conditions for Stage 2, except that the low-pass filter became operable at varying points. In Stage 3, an unstated number of "novice" pilots practiced the same control task with the general aviation aircraft simulation with varying delays and filter compensations. Practice continued until pitch and roll errors were less than 1 and 3 degrees, respectively. Ss were then tested for transfer on the same task using the high performance simulation.

RESULTS: Patterns of results were consistent, so all data were not reported. In Stage 1, roll errors increased systematically for zero to almost 1500 msec delays, and were roughly twice as great for high performance simulation. Stick deflections increased as well, but with less intersubject consistency in patterns. Crossover power was highly variable across subjects, with consistent (decreasing) trends apparent only for high performance simulation. In Stage 2, system

Key Number

errors decreased systematically for filter break frequencies ranging from .5 to 10 radians per second (r/s), while stick deflections decreased up to approximately 5 r/s and then increased. Crossover power increased up to 5 r/s, becoming irregular as the ratio increased to 10. Trials to criterion for novice Ss increased linearly with amount of delay, both when compensated and when not. Subjects appeared to use the same control style, however, regardless of delay or compensation. Transfer of skills was not affected either.

6 AUTHOR'S CONCLUSIONS:
Addition of a low-pass filter to a linear prediction of system states overcame the limitations of the linear method. Delay compensation can reduce number of training trials needed using systems with significant dead-time display delays. Negative transfer is no problem, at least if Ss practice to criterion originally. Improvements resulting from the compensation would probably be more "dramatic" for tasks where very small control tolerances must be satisfied over an extended period (e.g., air-to-air refueling).

7 EVALUATION:
Many details of procedure and data were omitted in this presentation to a conference. It appears nevertheless that the conclusions are justified by the regularities in the data. The conclusion regarding transfer should be qualified, however. The transfer was to a different configuration of the simulator, not to an aircraft. Also, the same control task was used. It is still possible for negative transfer to occur in different second tasks, and in an aircraft. Even so, the study was a worthy one and it was well reported.

14 DEPENDENT VARIABLES:
Pitch error; roll error; stick deflection; relative crossover power

15 INDEPENDENT VARIABLES:
Transport delay in a visual system; compensation via a low-pass filter

22 SYSTEM/CLASS:
Flight simulator

23 SUBJECT POOL:
"Experienced" pilots; "novice" pilots

24 NUMBER OF PAGES:
0008

Key Number	
25	NUMBER OF REFERENCES: 0007
28	RESEARCH CLASS: Experimental Analysis
29	RESEARCH METHOD: Formal experiment/multiple variable
36	REPORT TITLE: Compensating for Flight Simulator CGI System Delays
37	REPORT AUTHOR: Ricard, G. L.; Norman, D. A.; Collyer, S. C.
38	REPORT DATE: 76/11/00
40	ORIGINATING ACTIVITY: Naval Training Equipment Center, Orlando, Florida
52	PUBLISHER/SPONSOR: Naval Training Equipment Center, Orlando, Florida
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 007
15 December 1977

Key Number

1 ACCESSION NUMBER: AD-A030 405

4 CITATION:

Bunker, W.M.; Heartz, R.A. Perspective Display Simulation of Terrain. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-76-39, June, 1976.

5 ABSTRACT:

PURPOSE: The primary purpose of this study was to provide at least partial answers to three questions regarding electro-optical viewing systems (EVS) simulation: Which processing algorithms will meet training requirements in the most cost effective manner? What scene complexity is required? What data base format and data base preparation techniques should be used? A secondary purpose was "to determine the degree to realism attainable in terrain simulation . . . from the information available in the DMA (Defense Mapping Agency) data base."

SUMMARY: As a foundation for later analyses, a discussion of data format and preparation, and a description of computer image generation (CIG) algorithms were presented. The data format and preparation discussion included radar and CIG requirements and techniques for data compression. Three problem areas were then addressed: (a) application of CIG to EVS simulation; (b) comparison of CIG and radar approaches to EVS simulation; and (c) the application of radar simulation technology to EVS simulation. The concerns in problem area (a) were the maximum realism that can be attained from data on DMA data tapes, the question of need for maximum realism at a high cost when adequate scene detail could be attained with reduced realism, and the trade-offs of realism vs. detail as related to data preparation technology and CIG processing algorithms for curvature, noise, electronic transfer function, atmospheric effects, and texturing. Numerous illustrations of CIG images were provided to show variations in realism and detail corresponding to different data bases and algorithms. Actual photographs of terrain being simulated were compared with simulated images. For problem area (b) certain conditions for the generation of perspectively valid spatial images that must be met by both the radar and CIG approaches were discussed. The radar approach must scan the environment with a set of defined planes that will result in a pattern of scan lines that are nonparallel, unequally spaced, and at an arbitrary angle relative to the display device. On the other hand, the CIG can start with a set of scan lines that are parallel, equally

Key Number

spaced, and oriented in a preferred manner to the display device, with the environment-scanning planes being defined from this set. However, comparable scenes can be produced with either approach. Nevertheless the radar approach has the advantage in being relatively more simple and, within certain constraints, it validly handles the priority, or occulting, function for perspective displays. These constraints are that: "The trace of the scan line on the ground must correspond to increasing ground range . . . (and that) the edges must define the environment as a continuous, single-valued, function of the surface location." An additional constraint involving the pitch of the aircraft or sensor was alluded to but its relation to the radar approach was not clearly identified. For problem area (c), the application of radar technology to EVS simulation, the radar approach was analyzed in detail, with emphases on geometric relations of sensor angle to target, frame update rate, and parameters of an example radar system.

6 AUTHOR'S CONCLUSIONS:

(a) "Very realistic terrain displays can be produced using only DMA elevation data points as source data." (b) "Data base efficiency is significantly affected by the data format and compression technique." (c) "Real-time simulation hardware for training . . . is not only feasible but can be provided with minor modification (of) existing hardware designs." (d) "Where the constraints of the radar approach are not violated and where a radar-oriented approach and a CIG-oriented approach have identical characteristics in regard to smoothing and other processing parameters, the resulting displays will be indistinguishable."

7 EVALUATION:

This report has considerable relevance to terrain simulation displays but it is hard to follow. On the one hand the reader often is immersed in technical aspects of an issue with no preparation, while at other times the writing is discursive with no clear focus or point. Conclusions do not clearly address the questions given above under Purpose. However, the content of the report does address the questions, and the numerous figures help clarify the often confusing text.

14 DEPENDENT VARIABLES:

Realism in electro-optical viewing (EVS) simulation; detail in EVS simulation.

22 SYSTEM/CLASS:

Visual simulation/terrain display

Key Number

24 NUMBER OF PAGES:
0177

25 NUMBER OF REFERENCES:
0002

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Logical analysis and description

36 REPORT TITLE:
Perspective Display Simulation of Terrain

37 REPORT AUTHOR:
Bunker, W.M.; Heartz, R.A.

38 REPORT DATE:
76/06/00

40 ORIGINATING ACTIVITY:
General Electric Company, Daytona Beach, Florida

44 CONTRACT/PROJECT/TASK:
Project 1958 Training Simulator Technology/Task 195083, Advanced Sensor Simulation System

48 REPORT NUMBER:
AFHRL-TR-76-39

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 008
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Graves, R.D.; Kupiec, C.F. A Performance Measurement System for Training Simulators. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 21-35, 15-17 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the paper was to present a performance measurement system to optimize power plant operator training and to collect man-machine operational research data on a training simulator.
SUMMARY: This report describes a project by the Electric Power Research Institute to develop a prototype Performance Measurement System (PMS) for training simulators. A pilot implementation of the PMS was conducted on the Browns Ferry Simulator at the Tennessee Valley Authority (TVA) Power Production Training Center. An unstated number of TVA operators made twenty runs, each consisting of four exercises concerned with reactor criticality, reactor scram from power operation, plant startup, and main steam isolation valve closure. During each exercise, operational data were collected on magnetic tape and put into a computer program designed to evaluate reactor operator performance. Also, one or more experienced evaluators observed each exercise and completed a subjective evaluation checklist. Each exercise was videotaped and post-exercise interviews were conducted by consultants in human factors, selection testing, and modeling to obtain the operator's opinions of the exercise and his judgment of the relative difficulty of the required tasks. A computer printout detailed the reactor operator's performance according to errors occurring in a chronology of events. It also tabulated total numbers of errors on each exercise and times required by the operator to complete it. Finally, a complete tabulation of numbers and types of errors, separate by task, was provided on the printout. These printout data were converted into per cent grades which were compared with evaluators' subjective grades. The grades correlated "reasonably well," but there were "several exceptions to this close correlation in which the instructor evaluation and the computer evaluation (were) separated by more than several percent." Some discrepancies between grades were due to technical procedural factors alone, while others were apparently due to the inability of evaluators to attend fully to all details of certain complex operations.

Key Number

Furthermore, the computer and at least some evaluators used different bases for arriving at grades.

6 AUTHOR'S CONCLUSIONS:
The computer evaluation was "complete and exacting." It evaluated both the operator trainee and his instructor's evaluation of him. Video tape replays of the exercises were valuable as feedback to trainees. PMS data enhance training and are well suited to research endeavors.

7 EVALUATION:
The PMS provides useful performance measurement data on easy-to-read computer printouts. The generalizability of the PMS to other types of simulator training is apparent. Hence, it is relevant to military simulator performance measures.

14 DEPENDENT VARIABLES:
Simulator performance measures

22 SYSTEM/CLASS:
Simulators

24 NUMBER OF PAGES:
0015

25 NUMBER OF REFERENCES:
0002

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

36 REPORT TITLE:
A Performance Measurement System for Training Simulators

37 REPORT AUTHOR:
Graves, R.D.; Kupiec, C.F.

38 REPORT DATE:
77/11/00

40 ORIGINATING ACTIVITY:
General Physics Corporation

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

Key Number	
56	TYPE OF PUBLICATION: Presentation
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 009
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Kron, G.; Young, L.; Albery, W. High-G Simulation--The Tactical Aircraft Simulator Problem. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 49-59, 15-17 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the report was to provide a background to the development of current g-cueing devices in aircraft simulation and a discussion of future developments.
SUMMARY: The platform motion system is considered a low-range g-cueing device, adequate for simulation of transport but not tactical aircraft. Current mid-range g cueing devices include: (a) the g seat, which causes the somatic sensation in the buttock/back region perceived in the aircraft as a result of pilot/seat inertial coupling effects; (b) the g suit, which produces external pressure to the lower extremities; and (c) the seat shaker, which provides vibratory cues in the frequency range beyond that readily obtainable with cockpit motion systems. The g seat has several limitations. It delivers g stimuli only to the pilot/seat inertial coupling area, omitting cues arising from inertial load buildup in the arms, visceral inertia, etc. Most neck muscular stimuli associated with g loading are absent as well, as are those from head bobbing and skeletal structure. Link was awarded a contract by the Air Force to develop an advanced low-cost g-cueing system which has been designed and is currently under construction. It differs from the first generation g seat in that it: (a) departs "from a mosaic element cushion approach, but retains cushion attitudinal and elevation change capability"; (b) implements "thin cushion surface bladders for localized pressure and tactile area-of-contact stimuli generation"; (c) uses "hydraulic actuator servo systems to provide the desired response characteristics"; (d) adopts "passive rather than active seat pan thigh panels"; (e) implements "lower backrest radial elements to provide strong area-of-contact cues for vertical and longitudinal acceleration"; (f) uses a "differential lap belt drive for inclusion of lateral as well as longitudinal and vertical belt cueing"; and (g) adds "a seat pan longitudinal degree of freedom cascaded on seat pan cushion pitch, roll, and heave." Vibratory effects may be caused by the seat pan cushion itself, possibly resulting in the elimination of the seat frame shaker

Key Number

system. The g suit features a press-to-test and pressure/instructor input which are handled eletronically. More rapid suit pressuirization and exhaust are provided by a high volume pneumatic servo valve design serviced by compressed air and vacuum. The g-cueing system is supported by a control cabinet logic and sixteen servo loops. A current study will attempt to find means of generating g loading stimuli in the following areas: (a) shoulder harness; (b) head/helmet coupling; (c) limb loading; (d) aural effects; and (e) visual effects. It will also investigate the potential of stimuli production via body negative pressure, respiratory control, lacrimation control, and flesh pressure/temperature interrelationships. Another study was underway to develop a means by which pilot training, via the M-1 maneuver, can be sensed and used in the total simulation control loop to affect the dimming level of the visual display as a function of g.

6 AUTHOR'S CONCLUSIONS:
The g suit has been a milestone in mid-range cueing, but more advanced full-range g-cueing devices are needed to simulate the tactical environment.

7 EVALUATION:
This report is unusually well written. It contains an excellent summary of g simulation requirements, of earlier attempts to meet those requirements, and of steps that must be taken to overcome present shortcomings in g simulation.

8 COMMENTS:
Although the abstractor chose to classify this report as Status Study/Description because of an extensive treatment of a simulator design, it could also have been described as Status Study/Historical. The previous development of g simulation was presented as a foundation for the planned g system that was discussed.

14 DEPENDENT VARIABLES:
High g simulation

22 SYSTEM/CLASS:
G seat; g suit; seat shaker

24 NUMBER OF PAGES:
0011

Key Number

25 NUMBER OF REFERENCES:
0008

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

36 REPORT TITLE:
High-G Simulation--The Tactical Aircraft Simulator Problem

37 REPORT AUTHOR:
Kron, G.; Young, L.; Albery, W.

38 REPORT DATE:
77/11/00

40 ORIGINATING ACTIVITY:
Link Division, Singer Company; Department of Aeronautics and Astronautics, Massachusetts Institute of Technology; Advanced Systems Division, Air Force Human Resources Laboratory

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 010
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Barnes, A.G. The Effect of Visual Threshold on Aircraft Control, With Particular Reference to Approach and Flare Simulation. AIAA VISION AND MOTION SIMULATION TECHNOLOGY CONFERENCE PROCEEDINGS, Cape Canaveral, Florida, 16-18 March, 1970.

5 ABSTRACT:
PURPOSE: This study addressed a possible difficulty in transferability to aircraft of certain control techniques used in simulators. Specifically, it was hypothesized that "one of the inherent limitations of a fixed base simulator equates approximately to a dead-space (delay) in signals received by the pilot." This study was designed to determine the effect of varying amounts of deadspace on pilots' simulator performances and their assessments of the similarity of simulator behavior to that of aircraft.
METHOD: Preliminary to the experiment described in this report, analytical and computer investigations of the effect on closed loop stability of a dead-space in an autopilot's feedback loop were described. It was concluded that quite small imperfections in bank or heading servos in a flight simulator are possible sources of discrepancies between simulator and aircraft control operations. For the flight simulator experiment, experienced pilots viewed through collimating lenses and in true angles, a display consisting of an electronically generated symbolic presentation of a "lead" aircraft. The pilot's task was to formate behind the lead aircraft, line astern. After about fifteen seconds, he was to formate on one of the wing tips, again holding the position for about fifteen seconds. The pilot then returned to the center position. "The longitudinal control of the aircraft was by the autopilot. Neither turbulence nor target maneuvers were injected into the control loop. Forward speed was fixed at 120 knots. Force for full aileron control was approximately 10 lbs., and a maximum control gave a rolling acceleration of 1.4 rad/(sec squared)." The pilot did not know which dead-space case was operable, although reversion to the basic case (no dead-space) was allowed when requested. Variations of 0, 1, or 2 degrees dead-space in bank or heading were used. Plots of tracking performance were obtained and rated, and pilots were asked to assess the similarity of simulator behavior to that of an aircraft.

Key Number

RESULTS: Introducing a dead-space into either the bank or heading feedback loop caused a deterioration in both pilot assessment and performance. A 1-degree dead-space in heading had a greater destabilizing effect than a 1-degree dead-space in bank. There was an increase in limit cycle amplitude when the dead-space in the bank angle or heading feedback loop was increased to 2 degrees.

6 AUTHOR'S CONCLUSIONS:
"If a dead-space is introduced into the feedback loop, a low frequency limit cycle results. The amplitude and frequency of the limit cycle depend on the position of the dead-space, the feedback gain, and the size of the dead-space . . . many flight instances of low frequency pilot induced oscillations (may be) attributable to threshold phenomena." Furthermore, the occurrence of oscillations induced by pilots' visual thresholds is more likely in the flight simulator than in actual flight.

7 EVALUATION:
The study was well designed and reported. It is not clear, however, that because introduced dead-space affects experienced pilot performance, delays in signals in simulators will lead to an undesirable degree of negative transfer of simulator training. Rate of aircraft response varies widely to control inputs and pilots learn to adapt to the differences rapidly. If much negative transfer occurs, it will probably be for novices. Nevertheless, with current state-of-the-art technology, this type of delay poses no major problem.

14 DEPENDENT VARIABLES:
Aircraft/simulator control fidelity

15 INDEPENDENT VARIABLES:
Dead-space (delay) in simulator signals

22 SYSTEM/CLASS:
Flight simulators

24 NUMBER OF PAGES:
0009

25 NUMBER OF REFERENCES:
0009

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

Key Number

36 REPORT TITLE:
The Effect of Visual Threshold on Aircraft Control, With Particular Reference to Approach and Flare Simulation

37 REPORT AUTHOR:
Barnes, A.G.

38 REPORT DATE:
70/03/00

40 ORIGINATING ACTIVITY:
British Aircraft Corporation, Preston, England

49 REPORT NUMBER:
AIAA Paper No. 70-357

52 PUBLISHER/SPONSOR:
American Institute of Aeronautics and Astronautics, New York, N.Y.

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 011
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Dust, D.C. Color Closed-Circuit Television as a Means of Providing Visual Cues in Simulation. AIAA VISUAL AND MOTION SIMULATION CONFERENCE PROCEEDINGS, Cape Canaveral, Florida, 16-18 March, 1970.

5 ABSTRACT:
PURPOSE: The purpose of this report was to describe equipment and techniques used at NASA Ames Research Center to provide visual cues in simulation. It also provides some evaluative information regarding the equipment and techniques.
SUMMARY: At the time of this report the Ames Research Center had two commercially available visual flight attachment systems for providing visual cues during simulation research studies. Both were closed circuit television systems which provided color images of an airport and surrounding terrain, using a 3-dimensional model of the terrain. Cameras for both systems had six degrees of freedom of motion. System 1 used a fixed terrain model scaled at 600:1 while system 2 used a moving belt model scaled at 2000:1. Two kinds of output had been tried, both supplemented with appropriate lenses: projection of images onto a screen in front of the pilot; and color and black and white TV monitors. Comparisons of the systems with Air Transport Association (ATA) guidelines for visual acuity limits were made using mostly the fixed-model, 600:1 scaled system. For distances up to 3 miles ATA criteria were met except for discrimination of individual runway stripes at 2 miles and textural details at 1000 feet. Three types of trade-offs were discussed. The first concerned terrain models. The moving belt model, while requiring less floor space than the fixed model, did not provide a good approach and runway lighting system. However, plastic light-pipes and fiber-optic bundles rendered the fixed system adequate except that landing light intensities needed for TV detection at 6 miles were too intense for runway approach. Attempts to alleviate this problem were under way. The second trade-off concerned screen projection of image vs. monitor. The monitor system was brighter, had more contrast, had less inertia for the motion system to overcome, and was more reliable and easier to operate. However, it also had less resolution and more distortion. The third trade-off concerned color vs. black and white TV systems. Color provided more realism and better resolution. However, color

Key Number

systems cost 6 or 7 times as much as black and white to install and 1.5 times as much to maintain. Also, maintenance and operational personnel must be better trained for color systems.

7 EVALUATION:
This report is easy to follow and understand. Its main shortcoming is the lack of methodological description which was probably omitted because it was a conference presentation.

14 DEPENDENT VARIABLES:
Acuity in visual simulation

15 INDEPENDENT VARIABLES:
Image color; terrain model; screen projection vs. TV monitor

22 SYSTEM/CLASS:
Visual simulation

24 NUMBER OF PAGES:
0008

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Color Closed-Circuit Television as a Means of Providing Visual Cues in Simulation

37 REPORT AUTHOR:
Dust, D.C.

38 REPORT DATE:
70/03/00

40 ORIGINATING ACTIVITY:
NASA Ames Research Center, Moffet Field, California

49 REPORT NUMBER:
AIAA Paper No. 70-347

52 PUBLISHER/SPONSOR:
American Institute of Aeronautics and Astronautics, New York, N.Y.

Key Number

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 012
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Watkinson, D.T.; Bondurant, R.A.; Frearson, D.E. Development of a V/STOL Multi-Crew Research Simulator. AIAA VISUAL AND MOTION SIMULATION TECHNOLOGY CONFERENCE PROCEEDINGS, Cape Canaveral, Florida, 16-18 March, 1970.

5 ABSTRACT:
PURPOSE: The purpose of the study was to describe the development of a Vertical/Short-field Takeoff and Landing (V/STOL) multi-crew research simulator.
SUMMARY: The Multi-Crew Simulator (MCS) was developed for use in V/STOL Instrument Flight Rules (IFR) control-display research. Design requirements for the simulator were: (a) flexibility; (b) centralized experimental control; (c) full subsystem simulation; and (d) maximum visual, vestibular, and auditory realism. These requirements were met in several ways. Hardware and software were developed to provide an experimenter with rapid access to simulation status information and capability to modify rapidly the simulation dynamics. A C-135B trainer cockpit, modified to V/STOL configuration, provided a full subsystem simulation. A C-130 three degree-of-freedom motion system provided acceleration and position cues. A Link SMK-3 visual system provided six degrees of freedom externally and the capability to simulate visual breakout at low altitudes. The various characteristics of the MCS resulting from these subsystems were described in detail. A checkout program was conducted to: "assess the fidelity and rigor of the programmed math model and provide a baseline of model performance; and . . . determine the performance characteristics of the various subsystems both independently and collectively." The program consisted of two parts: mathematical model acceptance testing; and a MCS sample study. The mathematical model acceptance test conditions were extracted from XC-142A flight test data and covered short takeoff, climb, maximum speed, static directional stability, hover, hover ceiling, and descent. The sample study, which had not been completed, included seven phases: (a) control response test; (b) stability and control test; (c) visual system test; (d) motion system test; (e) visual and motion system capability; (f) hover handling qualities test; and (g) MCS steep angle approach evaluation. Data from the mathematical model acceptance test were within acceptable ranges of tolerance when compared with the flight

Key Number

tests. Results for the MCS sample study were not reported. It was felt that while the MCS was shown to be useful in simulation research, it could be capable of improvement. Also, the requirements for full task simulation were more than may have been required for initial application of the system.

7 EVALUATION:
This study was not completed before the time it was to be presented at a conference, and the report suffered because of the incompleteness. The mathematical model acceptance test was not described and the results were presented in a single sentence. No results from the sampling study were given. Nevertheless, the report is useful as a description of the MCS as designed.

22 SYSTEM/CLASS:
Vertical/Short-field Takeoff and Landing (VSTOL) multi-crew simulator

24 NUMBER OF PAGES:
0009

25 NUMBER OF REFERENCES:
0013

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

36 REPORT TITLE:
Development of a V/STOL Multi-Crew Research Simulator

37 REPORT AUTHOR:
Watkinson, D.T.; Bondurant, R.A.; Frearson, D.E.

38 REPORT DATE:
70/03/00

40 ORIGINATING ACTIVITY:
The Bunker-Ramo Corporation, Canoga Park, California; Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio

49 REPORT NUMBER:
AIAA Paper No. 70-356

52 PUBLISHER/SPONSOR:
American Institute of Aeronautics and Astronautics, New York, N.Y.

Key Number

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 013
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Hughes, R.J.; Mueller, L.J.; Miller, L.A.; Blume, G.E.; Sidley, N.A.; Lundberg, D.A. Air-To-Air Gunnery Part-Task Trainer. Systems and Research Center, Honeywell, Minneapolis, Minnesota, PTT-FR, 1 December, 1975.

5 ABSTRACT:
PURPOSE: The purpose of the study was to determine the training requirements for an aerial gunnery part-task trainer, to develop alternative designs for such trainers, and to evaluate the trainers' potential for providing effective, low-cost gunnery training.
SUMMARY: A literature survey and interviews with 18 pilots revealed three primary areas of training required in an aerial gunnery part-task trainer: perceptual training; low angle-of attack (.LT. 30 degrees) (LAO) training; and high angle-of attack (.GT. 30 degrees) (HAO) training. The need for such training as determined by criticality for mission success, difficulty in learning, and frequency of occurrence during missions, showed perceptual and HAO training to rank equally high, with LAO training ranking third. However, a payoff analysis showed that, due to a higher probability of kill, LAO training should be provided for in a trainer. Seven alternative trainer purposes/designs were discussed: (a) a minimal perceptual trainer devoted only to visual aspects of a gunnery task; (b) a perceptual trainer with closure rate control; (c) a perceptual trainer as in (b) but with a minimal gunnery trainer added that simulates dynamic aspects of LAO and HAO attacks; (d) a wide angle video trainer incorporating perceptual, LAO, and HAO training; (e) an air combat simulator incorporating the part-task trainer in (d); (f) a simulator as in (e) but simplified; and (g) a wide angle trainer as in (f) but without a spherical screen. Training requirements could be provided for perception by all seven alternatives; for HAO by (d), (e), and (g); and for LAO by (d) through (g). Evaluations were made of each alternative according to training requirements, capability options, and costs. The rank of costs of alternatives is approximately in the order given above, ranging from 64K for (a) to 531K for (g) for prototype development, and from 24K to 256K for recurring costs. A recommended configuration for a trainer similar to (e) was then discussed and capability/cost options explained.

Key Number

6 AUTHOR'S CONCLUSIONS:
Conclusions appeared as two recommendations. In the long term, a combination of two types of trainers should be used: a simple, highly portable perceptual trainer and a mo complex gunnery trainer. For the short term, a prototype o he gunnery trainer should be procured since it is capable providing both perceptual and gunnery training.

7 EVALUATION:
The analyses of trainer requirements assumed that, be usable, a device must provide realistic cues for ea type of task. An instructional analysis was needed to iden ify transferable cue and response complexes, and the extent to which physical and task fidelity are needed for teaching them.

14 DEPENDENT VARIABLES:
Conformity of an aerial gunnery part-task trainer to training requirements

15 INDEPENDENT VARIABLES:
Simulator complexity; simulator cost

18 SPECIAL ANALYSIS TECHNIQUES:
Subjectively based payoff analyses

22 SYSTEM/CLASS:
Part-task trainer/aerial gunnery

24 NUMBER OF PAGES:
0150

25 NUMBER OF REFERENCES:
0028

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Logical analysis and description

36 REPORT TITLE:
Air-to-Air Gunnery Part-Task Trainer

37 REPORT AUTHOR:
Hughes, R.J.; Muller, L.J.; Miller, L.A.; Blume, G.E.; Sidley, N.A.; Lundberg, D.A.

38 REPORT DATE:
75/12/01

Key Number

40 ORIGINATING ACTIVITY:
Systems and Research Center, Honeywell, Minneapolis, Minnesota

44 CONTRACT/PROJECT/TASK:
AFHRL Contract No. F33615-75-C-5288

49 OTHER NUMBER:
PTT-FR

52 PUBLISHER/SPONSOR:
Air Force Human Resources Laboratory (Sponsor)

56 TYPE OF PUBLICATION:
Final report

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 014
15 December 1977

Key Number

1 ACCESSION NUMBER: AD-A040 443

4 CITATION:
Cyrus, M.L. Energy Conservation Through the Optimization of Hydraulic Power Supplies for the Six Degree of Freedom Motion System. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-77-7, March, 1977.

5 ABSTRACT:
PURPOSE: The purpose of this study was to "estimate the approximate hydraulic fluid flow requirements for the six degree of freedom motion system of the type specified in MIL-STD-1558, and determine if possible the means by which motion hydraulic supplies can be cut, combined, or made more efficient."
METHOD: An unstated number of pilots flew two Advanced Simulators for Pilot Training (ASPT) in series of g contact maneuvers (loops, rolls, spins, etc.). Data were recorded concerning three types of variables: demanded cylinder extensions; actual cylinder extension; and discrete measures that specified which motion cues (translational, rotational, or gravity align) were active at a particular time. Eight parameters were derived from these data: (a) demanded flow rate above that necessary to maintain the system in an erect state; (b) actual flow rate; (c) demanded leg cylinder velocity distributions; (e) demanded positive velocity increments summed across all six legs in an upward (positive) direction; (f) actual positive velocity increments; (g) demanded negative velocity increments summed across all six legs; and (h) actual negative velocity increments. For each parameter, a mean, standard deviation, skewness coefficient, kurtosis coefficient, minimum value and maximum value were obtained. Frequency (power) estimates and their standard deviations from 0 to 3.75 Hz, in increments of (3.75/512) Hz, were also obtained for each of the eight parameters.
RESULTS: Only three kinds of data were reported, fluid flow, increases, and decreases, "because the shape of all distributions was similar." Time history distributions were very similar for "demanded" and "actual" measures, and between leg triad sets 1, 3, and 5, and 2, 4, and 6. Fourier transformation graphs showed almost identical patterns for "demanded" and "actual" flow, increases, and decreases, although the curve for "demanded" represented consistently higher magnitudes. The

Key Number

distribution of hydraulic flow requirements was highly skewed positively.

6 AUTHOR'S CONCLUSIONS:
The fact that "the vast preponderance of power lies to the left of (below) 1 Hz . . . coupled with the large skewing coefficient, indicates considerable savings may be made through consolidation of hydraulic power supplies . . . By using one or more large pumps, to handle the relatively constant demand from a combination of motion systems, and using smaller, faster reacting pumps, together with accumulators for the overflow, substantial reductions in hydraulic requirements and cost may be possible."

7 EVALUATION:
This report was well written but little detail wa. provided. Among the various measures used to describe the distribution, only that for skewness was mentioned in the text. Most of the others appeared in a table but their meanings were not explained. Thus the bases for the conclusions are not clear. For example, how would transport lag be affected by a consolidation of power supplies?

8 COMMENTS:
Although it was not stated as a conclusion, the greater magnitude of "demanded" fluid flows, increases, and decreases, and the comparable patterns of "demanded" and "actual" changes, "enables offline estimation of the effect of a variety of motion mathematical models on hydraulic flow . . . while still providing a safe, upper bound on what will really be used . . ."

14 DEPENDENT VARIABLES:
Distributions of fluid flow

18 SPECIAL ANALYTICAL TECHNIQUES:
"Fast" Fourier transform

22 SYSTEM/CLASS:
Six degree-of-freedom motion system

24 NUMBER OF PAGES:
0015

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Experimental Analysis

Key Number

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Energy Conservation Through the Optimization of Hydraulic Power Supplies for the Six Degree of Freedom Motion System

37 REPORT AUTHOR:
Cyrus, M.L.

38 REPORT DATE:
77/03/00

40 ORIGINATING ACTIVITY:
Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona

44 CONTRACT/PROJECT/TASK:
62703F; 11230301

48 REPORT NUMBER:
AFHRL-TR-77-7

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 015
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Caro, P.W. Platform Motion and Simulator Training Effectiveness. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 93-97, 15-19 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the article was to review research on the effect of platform motion upon simulator training and possibly resolve apparent contradictions in research regarding effects of platform motion.
SUMMARY: Simulator platform motion has been shown to be effective in pilot training by some studies but not by others. To account for this discrepancy, two types of motion were differentiated: maneuver motion, which arises within the control loop and results from pilot-initiated changes in the motion of the aircraft; and disturbance motion, which arises outside the control loop and results from turbulence or from failure of a component of the airframe, equipment, or engines. Disturbance motion provides alerting cues, while maneuver motion provides feedback to the pilot's control movements. While the alerting cues provided by disturbance motion were more effective than such cues from other sources, the feedback cues of maneuver motion have been shown to improve pilot control only in unstable aircraft. Examination of the research revealed that platform motion aided training when motion was of the disturbance type, whereas maneuver motion was ineffective in aiding training. Interviews with Air Force pilots and instructors about simulation yielded favorable opinions mostly for disturbance motion. Maneuver motion was credited with adding to realism but it did not relate specifically to particular training goals. In one simulator maneuver, motion cues lagged noticeably behind instrument displays, were not smooth, and hence actually hampered training. The absence of yaw disturbance motion cues in the A-7D and C-5A simulators was cited as a negative factor in training.

6 AUTHOR'S CONCLUSIONS:
The distinction between disturbance motion and maneuver motion aids in understanding prior research and pilots' reactions to the motion component of aircraft simulators. Also, "future motion system designs should be responsive to requirements to provide specific movements which cue specific pilot responses rather than . . . motions which simply correspond to motions of the simulated aircraft."

Key Number

7 EVALUATION:
The article is clear and well-organized. It is useful in providing an examination and explanation of conflicting results of previous research on the effects of platform motion on simulator training.

10 AUTHOR'S RESEARCH SUGGESTIONS:
Needed research on disturbance motion includes: "(1) analysis of requirements for disturbance motion cues associated with specific simulator training objectives; (2) development of models for the representation of critical components of such motion in simulators; and (3) determination of the effects on transfer of training of the presence and absence of such motion." Furthermore, "Because of the continuing concern over the costs associated with motion simulation, future research . . . should also examine the use of platform motion systems with limited axes of motion, g-suits and seats, and 'seat shakers' to determine whether the disturbance cues . . . can be represented adequately in such relatively low cost motion devices."

14 DEPENDENT VARIABLES:
Simulator training effectiveness

15 INDEPENDENT VARIABLES:
Platform motion

22 SYSTEM/CLASS:
Flight simulator/motion systems

24 NUMBER OF PAGES:
0005

25 NUMBER OF REFERENCES:
0013

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Critique

36 REPORT TITLE:
Platform Motion and Simulator Training Effectiveness

37 REPORT AUTHOR:
Caro, P.W.

Key Number

40 ORIGINATING ACTIVITY:
Seville Research Corporation, Pensacola, Florida

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 016
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Ashworth, B.R.; McKissick, B.T.; Martin, D.J., Jr. Objective and Subjective Evaluation of the Effects of a G-Seat on Pilot/Simulator Performance During a Tracking Task. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 61-79, 15-17 November 1977.

5 ABSTRACT:
PURPOSE: The purpose of the article was to describe a seat cushion designed to provide acceleration cues for aircraft simulator pilots and present the results of evaluative tests of its effectiveness.
SUMMARY: A g seat was designed with air pressure as "padding" and a noncompressible wood surface beneath the pocket of air. The initial air pressure allowed the pilot's two main support areas, the tuberosities, to touch the wood surface which slightly compressed the flesh. As accelerations increased (positive g), air was removed from the seat, causing the cushion material to be compressed and more of the pilot's weight to be supported by the area of the tuberosities. For negative g, air was added to the seat to remove all contact with the wood and to support body weight uniformly. The air cushion, made of pliable rubber, had four air cells per seat and back, with individual pressure controllers for each cell. The air control valve was a standard aircraft anti-g suit valve with the normal activating slug replaced by a motor that provided the linear actuation of the valve. The servo controller had a 35 millisecond time lag from seat command to seat pressure over the seat's full range of operation. The seat cells were subjectively scaled by six Langley Research Center (LRC) test pilots and two engineers making comparison flights in the LCR T-38 aircraft. To determine the effect of the g seat on the simulator pilot's performance, a tracking task was performed in NASA Langley's Differential Maneuvering Simulator using an F-14 simulation as the test aircraft. Two sets of Ss were used: The first contained two LRC test pilots who were experienced with the g seat and simulator; the second contained five NASA test pilots with little experience in the g seat and simulator. The flight task was new for all Ss and required S to track a maneuver flown by one of the test pilots and stored on permanent files for computer playback. The maneuver consisted of a 3g wind up-turn at a constant airspeed of 325 knots. The pilot's tracking reference was driven during each

Key Number

run from 10 degrees lead to 5 degrees lag and vice-versa every 10 seconds, causing the pilot to reacquire the target every 10 seconds, thus increasing and decreasing g from the 3g nominal point. The LRC pilots flew 7 sessions of 10 runs each while the NASA pilots flew 4 such sessions each. Each run lasted 70 seconds and alternated seat-on, seat-off conditions. Variables recorded were: vertical tracking, lateral tracking error, total tracking error, normal acceleration, pitch rate, roll rate, range to target, reticle command, stick deflection for pitch, stick deflection for roll, rudder deflection, reticle switching time, and time. Performance measurements were arithmetic means, variances, and maximum and minimum values for each variable. Statistical analyses included t tests for paired and unpaired data and F tests.

RESULTS: The range of transition times for each pilot showed that a wide variety of approaches to tracking the target were used by both sets. Results of the F tests showed that over 90% of the significant measures for both pilot sets combined have lower variances for the seat-on condition, indicating that the seat provided the pilot with information aiding in more precise control of the aircraft. Subjective evaluations by the pilots indicated that the g seat aided in a more gentle ha- -ng of the airplane. These evaluations were verified b- -ean values for aircraft parameters (pitch rate, norm- -eration, longitudinal stick position), and means for the l- -udinal performance measures (vertical tracking error, transition time). The pilots' comments that the plane was "easier to control" or "better damped" in roll with the seat on were verified by the large number of significant measures in the variances and means for lateral-directional measures. The pilots indicated good to excellent realism for the normal acceleration cues. No time lag was noticed.

6 AUTHOR'S CONCLUSIONS:

Objective and subjective evaluations of the effect of the g seat on pilot performance during a tracking task showed that it gave information allowing more precise control of the aircraft. A surprise result was the positive effect of the g seat on lateral control problems.

7 EVALUATION:

The organization of the article, while perhaps adequate for oral presentation, is sometimes confusing. For example, part of the method section is mixed in with results. The article is useful in describing a g-seat design and its effectiveness in a tracking task, but results are hard to interpret because of the probable use of an inappropriate statistical test. All g-seat and non g-seat data were collected on the same Ss, and it is

Key Number

not clear whether correlated t tests were always used for such comparisons or when the unpaired t test was even needed. Also, no mention was made of data correlations in connection with the F tests, which in usual form are valid only with independent variance estimates. No data were given, only p values, so the reader cannot check the appropriateness of tests.

14 DEPENDENT VARIABLES:
Pilot accuracy in a tracking task

15 INDEPENDENT VARIABLES:
G seat

16 MEASUREMENTS/STATISTICAL METHODS:
F test; t test

22 SYSTEM/CLASS:
G seat

24 NUMBER OF PAGES:
0019

25 NUMBER OF REFERENCES:
0003

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Objective and Subjective Evaluation of the Effects of a G-Seat on Pilot/Simulator Performance During a Tracking Task

37 REPORT AUTHOR:
Ashworth, B.R.; McKissick, B.T.; Martin, D.J., Jr.

38 REPORT DATE:
77/11/00

40 ORIGINATING ACTIVITY:
NASA Langley Research Center; Sperry Support Services

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

Key Number

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 017
20 November 1979

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Vruels, D.; Goldstein, I. In Pursuit of the Faithful Few: A Method for Developing Human Performance Measures for Training Control. SEVENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 227-236, 19-21 November, 1974.

5 ABSTRACT:
PURPOSE: The presentation reviewed a program of previous research to develop a method for producing and selecting performance measures for training.
SUMMARY: Measures should be selected so that a minimum set would eliminate redundancy, would be sensitive to skill changes during training, and could predict performance. Four general steps are involved: (a) candidate measures are identified; (b) transformations of the data (e.g., summarizations) are prescribed; (c) conditions for starting/stopping measurement are specified; (d) measures are obtained and analyzed via multivariate techniques. The general model for automated measurement defines each measure in terms of a maneuver segment; a suitable parameter; sampling rate; a desired value (if applicable); a tolerance value (if applicable); and a transformation. Four techniques had been explored for selecting measures. UNIVARIATE examined each measure separately for significance of change during training. REDUNDANCY ELIMINATION identified measures with high intercorrelations which permitted some selection on the basis of unique information. DISCRIM SELECT used a computer for multiple discriminant analysis to discard measures based on their discriminative contribution within a total set. Elimination ceased when the number of remaining measures were fewer than the minimum number of factors required to account for the total variance, or when a measure, if discarded, would have unacceptabily reduced the overall discrimination level. CANON SELECT related measures of performance at one time with those at a later time, and derived linear combinations of the two sets such that the correlation between the two sets as wholes was maximized. Iterative CANON SELECT analyses were repeated, dropping measures on a predetermined basis, until only three measures remained. Finally, various results were reviewed and a final set was formed for recommended usage. An example measurement study was described that illustrated the procedures for obtaining data for and results from the various analyses.

Key Number

7 EVALUATION:
Some studies of pilot training have used up to 500 measures as dependent variables, and 100-200 are common in some quarters. Analyses of the results have necessarily been uninterpretable in any strict sense. This paper described a set of techniques for ordering measures so that their meanings can be defined in terms of relatively small subsets. The chaos introduced by multiple measures whose values are indeterminable can thus be avoided. The techniques applied are standard; however, nonstandard creative use of them was evident.

10 AUTHOR'S RESEARCH SUGGESTIONS:
More needs to be known regarding the sizes of samples needed for measurement studies. Also, additional work is needed "to explore predictive relationships in the present data and to clarify the role of prediction in future, more complex adaptive training systems."

16 MEASUREMENT/STATISTICAL METHODS:
Discriminant analysis; canonical correlation

22 SYSTEM/CLASS:
Automated performance measurement

24 NUMBER OF PAGES:
0010

25 NUMBER OF REFERENCES:
0008

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Theory development

36 REPORT TITLE:
In Pursuit of the Faithful Few: A Method for Developing Human Performance Measures for Training Control

37 REPORT AUTHOR:
Vruels, D.; Goldstein, I.

38 REPORT DATE:
74/11/00

40 ORIGINATING ACTIVITY:
Canyon Research Group, Inc., Westlake Village, California; Human Factors Laboratory, Naval Training Equipment Center, Orlando, Florida

<u>Key Number</u>

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Presentation

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 018
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Stark, E.A.; Bennett, W.S.; Borst, G.M. Designing DIG Images for Systematic Instruction. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 147-155, 15-17 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the report was to present points to be considered in the selection of visual information for digital image generation (DIG) systems.
SUMMARY: A method was presented to produce DIG images which would optimize flight training through various stages and complexities by identifying minimal cues for each task, subtask, and trainee level. The method is designed to identify the cues required at each skill level and to define the kinds of natural and programmed feedback needed to enhance learning. It includes a task analysis for visual system design covering several points; analyses of flight maneuvers for their visual information content; and identification of the minimum information, varying with control inputs, which the trainee can readily perceive. As the student progresses in his grasp of the percepts associated with individual task elements, the cues which can be added should be identified. Cues which are not only minimally essential, but perceptually consistent should be identified. The capabilities of the DIG in training should be considered. The DIG permits visual feedback to be programmed as appropriate. It can portray relatively distinct differences among similar conditions within missionlike task contexts. The DIG also permits the "incorporation of enough visual cues to simulate realistic pilot workloads to support practice in time-sharing and the division of attention frequently required in operational flight systems." The scenes and scene elements relevant to the specific learning task at hand should be developed systematically.

7 EVALUATION:
A distinct value of this report is its focus on cues needed for simulator training rather than on physical fidelity. The authors' alternative could result not only in less expensive visual systems, but in more effective simulator training, for they provided for varying cue complexity as indicated by students' progress.

Key Number

22 SYSTEM/CLASS:
Visual system/digital image generation

24 NUMBER OF PAGES:
0009

25 NUMBER OF REFERENCES:
0008

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Logical analysis and description

36 REPORT TITLE:
Designing DIG images for Systematic Instruction

37 REPORT AUTHOR:
Stark, E.A.; Bennett, W.S.; Borst, G.M.

40 ORIGINATING ACTIVITY:
Link Division, Singer Company, Binghamton, New York

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 019
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Dorsey, J.T. F-15 Aircraft Flight Simulator Student Performance Monitoring and Scoring. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida 181-196, 15-17 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the article was to describe the design and method of operation of a student performance monitoring and scoring system in the F-15 flight simulator.
SUMMARY: The student's flight performance, involving the ability to fly approaches to or departures from selected airfields, and his tactical performance, involving his techniques and success in releasing weapons at ground or airborne targets, can be monitored and scored in the F-15 simulator. Before flight, the Instructor Pilot (IP) selects one of a library of approaches or departures to be displayed on a large cathode ray tube (CRT) and segments it into separate legs. The legs are entered on disc files associated with the CRT data for the airfield picture using the "MOD SUPPORT" mode. Also entered are variables to be monitored during each leg, variables to define the end of each leg, the tolerances these values must meet, time delay on any scoring leg, etc. The IP may call up one of the stored airfield plates onto a display CRT during the mission. Twenty-two flight parameters are saved once per second when the student flies within a 20nm circle around the field. The IP may observe these flight parameters on the center CRT while "bugs" representing the F-15 position, one on the airfield plate plan view and another on the side view, are flying to scale on the right hand CRT. When the mission is completed the IP may score the student's approach or departure for as many as five fields flown. A grade of 100 with deductions proportional to time and magnitude of flight error is assigned. The airfield name, approach or departure name, the student's score and each error event, described by parameter and when, how much, and how long it occurred, are displayed. Each approach or departure receives a separate score. A hard copy of the CRT-displayed scoring page can be made. Tactical monitoring and scoring may be performed on the same or a separate mission. Before the mission, the IP may select up to 15 emitter-targets (ETs) to come into radar view. MOD SUPPORT is used to set up the type (ground, airborne, emitter, ET), location (for ground target),

Key Number

and range, bearing, altitude, and path (for airborne targets). The student must report the ET via radio, achieve radar lock-on, and select and release the appropriate weapon. The data at time of weapon release are saved along with other pertinent data depending on the mode of attack (air-to-air, air-to-ground) and displayed with the "hit or miss" calculation based on ET path and weapon trajectories or on ET firing envelope for certain weapons. An average score for the release of all weapons is calculated, with individual scores ranging from zero (miss) to 4 (hit). The center CRT will display the ET number, the hit or miss code, and other pertinent data depending on the attack mode so that the IP may score the tactical performance. Hard copy may also be made of this display. Additional scores which could be provided for a more comprehensive test of the student's skill by this system were outlined.

7 EVALUATION:
The article is very well organized and presents a clear picture of the scoring system, helpfully illustrated by several figures. The system is very versatile in that maneuver segments of interest can be isolated for monitoring. Hard copy capabilities provide permanent records for detailed examination and scoring.

14 DEPENDENT VARIABLES:
Student performance monitoring; student performance scoring

22 SYSTEM/CLASS:
F-15 flight simulator

24 NUMBER OF PAGES:
0017

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

36 REPORT TITLE:
F-15 Aircraft Flight Simulator Student Performance Monitoring and Scoring

Key Number

37 REPORT AUTHOR:
Dorsey, J.T.

38 REPORT DATE:
77/11/00

40 ORIGINATING ACTIVITY:
Goodyear Aerospace Corporation, Akron, Ohio

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 020
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Povenmire, H.K.; Russell, P.D.; Schmidt, D. Conservation of People, Planes, and Petroleum Through Optimized Helicopter Simulation. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 231-239, 15-17 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the article was to describe and evaluate a helicopter pilot training program using the Variable Cockpit Training System (VCTS) simulator.
SUMMARY: The VCTS helicopter pilot training program was described which focuses on training students to operate aircraft systems in all normal and emergency conditions. The program utilized proficiency-based advancement and training managers who take their students entirely through the training program. The VCTS includes two flight simulators, one for the U.S. Coast Guard's HH52-A helicopter and one for its HH-3F helicopter. Each contains a single Datacraft 6024/3 computer with a high-speed disc operation system. Six degrees of freedom are provided by a six-post synergistic motion system. Two students operate the simulator together, one acting as copilot. The instructor pilot sits behind them but does not interact with them. He monitors their performance and operates simulator controls. The simulator has the following capabilities: (a) automated demonstration of stored maneuvers performed by experts; (b) performance feedback of from one to five minutes of simulated flight; (c) automated performance scoring of frequency of instances and time out of tolerance for each of twelve aircraft parameters; and (d) in-cockpit control of all training and environmental conditions by the instructor. A program evaluation was conducted by means of critiques provided by students and their commanding officers, and by automated performance scoring of an instrument checkride in the simulator at the beginning and end of each student's training. The critiques indicated "basic satisfaction with the level of training received." The performance data indicated that the level of pilot proficiency has improved during the years of simulator use, and that the training program was raising pilot skill levels. After the evaluation several program changes were made. Average time savings in excess of 30 hours per student were realized in one course, five hours in a second, and seven hours in a third. A new proficiency course, which centralized and

Key Number

intensified the instrument and emergency procedures training that was previously done at separate units, reduced annual training requirements for each aviator by 12 hours. Monetary savings in 1976 were in excess of $2 million. One aircraft is known to have been saved as a result of a specific type of emergency malfunction procedures training in the VCTS simulator.

7 EVALUATION:
The report revealed advantages of the VCTS program in terms of training time required, cost, and safety. It is difficult to ascribe the strengths of the program to any particular set of factors, but certainly the extensive program preparation, proficiency advancement coupled with training managers rather than just instructors, and continued pairing of students with the same instructor-managers contributed to overall training efficiency.

22 SYSTEM/CLASS:
Variable cockpit helicopter training system

24 NUMBER OF PAGES:
0090

25 NUMBER OF REFERENCES:
0009

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Conservation of People, Planes, and Petroleum Through Optimized Helicopter Simulation

37 REPORT AUTHOR:
Povenmire, H.K.; Russell, P.D.; Schmidt, D.

40 ORIGINATING ACTIVITY:
Aviation Training Center, U.S. Coast Guard

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Presentation

Key Number	
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 021
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Kirby, G.T. Digital Computers in Training Devices: Trends and Forecasts. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 261-270, 15-17 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the article was to report trends and forecasts for the use of digital computers in training devices.
SUMMARY: There is a continuing trend toward rapid growth of digital computer-controlled training equipment. The increases in the number of programming languages, different computer models, number of computer manufacturers, memory sizes, and complexity of weapon systems to be simulated have resulted in support problems. Better reliability and performance and a reduction in computer hardware cost will result from the use of large-scale integrated chips. The cost of computer instruction should decrease exponentially. Microprocessors are improving the accuracy, flexibility and economy of instrumentation and control systems, and are rapidly appearing along with micro-computers in training equipment. Currently, software accounts for 70 to 80 per cent of total system cost; this figure is predicted to reach 90 per cent in the 1980's. The very large proportion of this amount which is presently spent on software maintenance must be decreased by more structured software design in the future. Automatic programming systems and a Code Auditor program for Automated Standards compliance checking are new developments. The magnetic core remains the most popular memory in the Navy inventory, followed by the magnetic disc and integrated circuit memory. The Charge Coupled Device and bubble memories may replace disc memories in the mid-1980's. Semi-conductor devices which will form the mainstream computer technologies in the 1980's were listed. Due to the large investments that computer manufacturers have in software, computer hardware technology is not expected to produce any major revolutions in the next decade. However, new weapon systems and operations will necessitate changes in computer hardware and software that support training equipment.

Key Number	
7	EVALUATION: The article is clear-cut, expressive, and identifies conflicting trends in the uses of digital computers in training devices. While the investments in software are a deterrent to hardware changes, emerging device requirements (and probably competition) will probably make the author's prediction of change come true.
22	SYSTEM/CLASS: Digital computers for training devices
24	NUMBER OF PAGES: 0010
25	NUMBER OF REFERENCES: 0012
28	RESEARCH CLASS: Status Study
29	RESEARCH METHOD: Normative
36	REPORT TITLE: Digital Computers in Training Devices: Trends and Forecasts
37	REPORT AUTHOR: Kirby, G.T.
38	REPORT DATE: 77/11/00
40	ORIGINATING ACTIVITY: Naval Training Equipment Center, Orlando, Florida
52	PUBLISHER/SPONSOR: Naval Training Equipment Center, Orlando, Florida
56	TYPE OF PUBLICATION: Presentation
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 022
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Sigmund, F.A. The Efficiency of FORTRAN in Simulation Computers. TENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS, Orlando, Florida, 281-290, 15-17 November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the article was to discuss the effects of using FORTRAN in computer systems for training simulators.
SUMMARY: The analysis of FORTRAN efficiency included: a comparison of Harris FORTRAN with assembly (sic) language efficiency; a comparison of two optimizing compilers designed for the same computer; and two FORTRAN benchmark programs used to measure the relative performance capabilities of potential simulation computers and their FORTRAN compilers. Compared to assembly language, optimized FORTRAN yielded an average memory size penalty of 17% and time penalty of 16% for four types of processing: bit (unpacked data); logical operations; floating point arithmetic; and basic instructions, i.e., transfers, integer arithmetic, branches, compares, shifts, and byte operations. (Without optimization the penalities were 59% for memory and 40% for time.) FORTRAN was inadequate for single bit manipulation, input/output, and interrupt processing. Benchmark totals similarly showed a 19% memory penalty and a 16% time penalty. In a comparison of FORTRAN 4 vs. FORTRAN 7, the latter compiler with more extensive optimization produced a 32% savings in memory and a 23% savings in time over FORTRAN 4. Benchmark results for seven candidate computers exhibited a wide range of memory and execution time efficiencies.

6 AUTHOR'S CONCLUSIONS:
Penalties for minimal execution time and memory are incurred for most types of processing, i.e., FORTRAN, performed in training simulators. An optimizing compiler is essential for FORTRAN, preferably one that performs extensive optimization. Benchmark results must be compared to assess relative efficiencies of candidate computers.

7 EVALUATION:
The article is very clear in showing the advantages of assembly language, and the need for optimizing FORTRAN processing.

Key Number

14 DEPENDENT VARIABLES:
Reduction in computer memory requirements; computer processing time

15 INDEPENDENT VARIABLES:
Program language; FORTRAN optimization

22 SYSTEM/CLASS:
Computer language

24 NUMBER OF PAGES:
0010

25 NUMBER OF REFERENCES:
0007

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
The Efficiency of FORTRAN in Simulation Computers

37 REPORT AUTHOR:
Sigmund, F.A.

40 ORIGINATING ACTIVITY:
Simulator Systems Engineering Department, Goodyear Aerospace Corporation, Akron, Ohio

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 023
15 December 1977

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Eggemeier, F.T. Two Short-Term Techniques for Gathering Training Device Requirement Information. PROCEEDINGS OF THE HUMAN FACTORS SOCIETY 21ST ANNUAL MEETING, San Francisco, California, 485-489, 17-20 October, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the study was to compare two short-term techniques for gathering training device requirement information.
METHOD: Two contractors each developed a short-term technique for specifying device training requirements for an aerial gunnery part-task trainer. One contractor used only interviews with 18 pilots experienced in aerial gunnery, while the second used questionnaires followed by interviews with 17 subjects with similar experience. The interview by the first contractor concentrated on defining specific cues and behaviors required in air-to-air gunnery in the operational environment. The questionnaires and follow-up interviews of the second contractor also emphasized these factors but in addition obtained pilot's opinions regarding specific features that should be included in a training device. These procedures were termed, respectively, the Operational Environment Technique (OET) and the Trainer Capabilities Technique (TCT). Questions used in both techniques were derived from surveys of literature and available documentation, and trial uses of the questions preceded data collection. All interviews by each contractor were conducted during a one-week period. Data were analyzed by training psychologists and simulation engineers in each instance, and each contractor recommended a device configuration capable of satisfying derived training requirements at a minimum cost.
RESULTS: Both techniques identified essentially the same set of behavioral training requirements for a gunnery part-task trainer. However, the device configurations differed in significant respects. The design resulting from OET was less extensive and lower in fidelity than that resulting from TCT. The latter included "more cockpit instrumentation, . . . more secondary aural and kinesthetic cues, a higher fidelity visual system, more performance measurement capability, and more instructional features . . ." Estimated costs for the TCT design were approximately four times that of the OET design.

Key Number

6 AUTHOR'S CONCLUSIONS:
The specification of behavioral requirements to be accomplished in a device can be fulfilled by either technique. However, the translation of behavioral requirements into required levels of fidelity was apparently affected by pilots' opinions regarding features that should be included in a device, rendering the TCT based design more extensive and of greater fidelity. Ultimately, transfer of training data must be used to evaluate the two techniques. Hence, an "optimal design strategy might therefore involve a mix of short and long term techniques," the latter providing an extended interaction between designers and users.

7 EVALUATION:
This well written report not only compares two short-term techniques for identifying behavioral training requirements, it also in the discussion puts the techniques in perspective by imposing an ultimate criterion of training effectiveness. It is not clear, however, that all differences in device design complexity are due to the techniques employed. Contractor propensities could be a factor as well.

14 DEPENDENT VARIABLES:
Gunnery part-task trainer design

15 INDEPENDENT VARIABLES:
Techniques for ascertaining behavioral training requirements

22 SYSTEM/CLASS:
Part-task trainer/gunnery

24 NUMBER OF PAGES:
0005

25 NUMBER OF REFERENCES:
0006

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Informal experiment

36 REPORT TITLE:
Two Short-Term Techniques for Gathering Training Device Requirement Information

37 REPORT AUTHOR:
Eggemeier, F.T.

Key Number	
38	REPORT DATA: 77/10/00
40	ORIGINATING ACTIVITY: Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio
52	PUBLISHER/SPONSOR: Human Factors Society, Santa Monica, California
56	TYPE OF PUBLICATION: Presentation
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 024
6 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Adams, J.A.; Hufford, L.E. Contributions of a Part-Task Trainer to the Learning and Relearning of a ime-Shared Flight Maneuver. HUMAN FACTORS, 4, 159-170, 1962.

5 ABSTRACT:
PURPOSE: The purpose of the first of two experiments was to determine the importance of time-sharing in the original learning of certain cockpit and flight control procedures. The second experiment sought to determine the value of a cockpit procedures trainer (CPT) in the reacquisition of the original learning after a 10-month period.
METHOD: 16 Ss comprised the experimental group in experiment 1 (E1) and 14 the control group (C1). All subjects were male, held valid private pilot certificates with 100 hours or less of flying time, and most were university students. None had experience in instrument flying or in SNJ aircraft or simulators. E1 Ss practiced flight control responses separately from procedural responses using an adapted simulator that was in a static condition during procedural training. C1 Ss practiced flight control and procedural responses simultaneously as required for the simulated mission. The flight task was unfamiliar to all Ss and was designed to require considerable time-sharing for the two types of responses. After training each S participated in 12 criterion trials, receiving feedback regarding his performance after each trial. For experiment 2, 10 of the original C1 Ss comprised a second control group (C2) and participated in whole-task practice as before. The E2 group, comprised of 10 original E1 Ss, first was given 10 trials in a CPT to practice the required procedural sequence, and was then shifted to whole-task practice comparable to that for C2. Both C2 and E2 completed 10 whole-task trials. Twelve performance scores were obtained on three flight phases and 10 procedural responses.
RESULTS: E1 Ss were superior to C1 Ss on both procedural and flight control learning during early trials when E1 Ss were practicing these responses separately. However, E1 Ss were inferior (p .LT. .02) on cockpit procedures on their first whole-task trial, but the inferiority was not evident on subsequent whole-task trials. No differences between groups were found in flight control performance after E1 Ss entered whole-task practice. In experiment 2, it was found at the outset that the "forgetting of procedural responses (was) virtually

Key Number

complete over the retention interval of 10 months." For the first four whole task trials, E2 was superior to C2 on procedural measures (p .LT. .01) although no differences were observed for trials 5-10. Both groups were equally inferior in procedural performances on the first whole-task trial when compared to the last such trial in experiment 1, and even though E2 had re-attained procedural competence in the CPT. As for flight control in experiment 2, E2 was slightly inferior on banking performance on the first whole-task trial when compared to their performance on the last trial of experiment 1, and both groups were inferior in comparable comparisons on vertical speed control. During relearning, E2 was superior to C2 on trials 2 (p .LT. .01) and 4 (p .LT. .05).

6 AUTHOR'S CONCLUSION:

Time-sharing affects both original learning and relearning. Procedural responses cannot be fully mastered in a CPT but require also some integrative whole-task practice. Forgetting of procedures was almost complete over a 10-month period, and whole-task practice was necessary to reinstate them. Nevertheless, the CPT is useful in training and can be used to reduce simulation time.

7 EVALUATION:

At the time these experiments were conducted, there was some question as to whether procedural and flight control training could be taught as part-tasks. These experiments clearly showed that for the flight tasks used, some whole-task training was necessary. However, the question of how much whole-task training is necessary was not answered. The authors could have made a stronger case for the value of the CPT and perhaps part-task training by emphasizing that E1 Ss were inferior to those in C1 only on their first whole-task trial. Also, a remaining question regarding possible interactons of experiment 1 training procedures with experiment 2 relearning procedures could perhaps have been resolved if half the Ss in each C2 and E2 had been drawn from C1 and E1. Instead, all C2 Ss were in C1, and all E2 Ss were in E1. An additional difficulty was a complete reliance on the t test which required numerous trial by trial comparisons. False positive results were thus considerably more likely and may be the case in trials 2 and 4 comparisons in which E2 was superior to C2. A repeated measures ANOVA was clearly needed which would reduce all sets of comparisons to single tests.

14 DEPENDENT VARIABLES:

Cockpit procedural responses; flight control

15 INDEPENDENT VARIABLES:

Part-task vs. whole-task training

Key Number

16 MEASURMENT/STATISTICAL METHODS:
t test

20 APPARATUS/MEDIA USED:
SNJ simulator; cockpit procedures trainer

23 SUBJECT POOL:
Males with private pilot certification

24 NUMBER OF PAGES:
0012

25 NUMBER OF REFERENCES:
0013

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

36 REPORT TITLE:
Contributions of a Part-Task Trainer to the Learning and Relearning of a Time-Shared Flight Maneuver

37 REPORT AUTHOR:
Adams, J.A.; Hufford, L.E.

38 REPORT DATE:
62/00/00

40 ORIGINATING ACTIVITY:
Aviation Psychology Laboratory, University of Illinois, Urbana-Champaign, Illinois

44 CONTRACT/PROJECT/TASK:
N6 1339-297

52 PUBLISHER/SPONSOR:
U.S. Naval Training Device Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

Key Number	
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 025
6 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
DeBerg, O.H.; McFarland, B.P.; Showalter, T.W. The Effect of Simulator Fidelity on Engine Failure Training in the KC-135 Aircraft. AIAA VISUAL AND MOTION SIMULATION CONFERENCE PROCEEDINGS, 83-87, 26-28 April, 1976.

5 ABSTRACT:
PURPOSE: The purpose of the study was to investigate the effect of simulator fidelity on engine failure training in the KC-135 aircraft.
METHOD: Thirty-six U.S. Air Force pilots who were KC-135 aircraft commanders served as Ss. The Flight Simulator for Advanced Aircraft (FSAA), an engineering research simulator, was chosen for the study because it was able to generate the yaw, roll, and lateral motion cues which an outboard engine failure would generate. A modified Redifon system (VPA-07) provided the visual display. The study was divided into three phases. In Phase I, pilot familiarization with the FSAA, the Ss flew eight Instrument Landing System (ILS) approaches with different wind and ceiling conditions. On the last two flights, deviation from glide slope was recorded and used to assign Ss to four groups which were matched for both mean and variance of ILS error score. In Phase 2, each pilot was trained by one of four cueing systems to respond to engine failure during take-off. The different cueing systems were: (a) no motion/no visual, (b) motion only, (c) visual only, and (d) combined motion and visual. Each S experienced 20 engine failures, half occurring at an altitude of 47 feet and half occurring on the ground at a velocity of 140 knots. In Phase III, the criterion phase, training effectiveness was assessed. All Ss experienced nine engine failures in the FSAA with unrestricted motion and visual cues. Thirty-four aircraft performance variables were recorded during this phase. Additionally, Ss completed a questionnaire after each phase of the study.
RESULTS: The values of the 34 variables were reduced using multivariate statistical analyses to identify a set of variables which best discriminated between the four cueing systems. Yaw and roll related variables were the most representative and critical in determining quality of engine-out performance. For engine failures occurring on the ground, motion and visual cues used alone yielded performance inferior

Key Number

to the other two conditions (ps will not be given; see EVALUATION). When visual and motion cues were used together, superior performance was shown. Both yaw and roll variables exhibited a visual by trials interaction in that initially there was a superiority of those trained with visual cues; but as more trials were run, the significance of visual versus no visual disappeared. For engine failures occurring in flight, the motion cue was superior in increasing the transfer of training effectiveness. A visual by trials effect was again significant for the yaw variable. The results of the questionnaires indicated a high acceptance of visual cueing systems and a low acceptance of systems without visual cues.

6 AUTHOR'S CONCLUSIONS:

The lack of statistical significance for the visual system in flight failure data is understandable since the attitude of the aircraft at the point of failure is such that few visual cues are available. Pilots use whatever cues are available, even if such cues are inappropriate. Pilots in the visual-only cueing systems performed worse than those in systems with no visual or motion cues, even though the same information was available through their instruments. The greatest improvement in training effectiveness occurred when both visual and motion cues were used together as compared to when either system was used alone.

7 EVALUATION:

This well written report describes an equally well designed experiment. However, serious analytic errors leave the interpretation of results in doubt. Specifically, the four groups in Phase 2 were matched on means and variances of ILS scores obtained in Phase 1. The repeated measures ANOVA used to analyze data assumes independent groups. Thus, Fs for Motion, Visual, and Motion by Visual interactions are too small. In fact, values as low as .01 and .02 were reported, indicating a high degree of restriction due to matching. Thus, it could have been likely that an appropriate test would have shown the effects discussed under RESULTS to have been more significant than the authors believed. But on the other hand, an even more serious error may have been made that rendered the ANOVAS meaningless regardless. The multivariate analysis that showed yaw and roll to be most discriminating was apparently completed before the ANOVAS. With 34 variables total, the odds that at least one of them would appear significant by pure chance are roughly six to one. The results cannot be interpreted except to say that they suggest a possible motion-visual joint effect, a possibility that should be investigated.

Key Number	
14	DEPENDENT VARIABLES: Pilot performance during engine failure
15	INDEPENDENT VARIABLES: Motion and visual cues during training
16	MEASUREMENT/STATISTICAL METHODS: Analysis of variance
22	SYSTEM/CLASS: Flight Simulator for Advanced Aircraft with visual system
23	SUBJECT POOL: U.S. Air Force pilots who were KC-135 commanders
24	NUMBER OF PAGES: 0005
25	NUMBER OF REFERENCES: 0000
28	RESEARCH CLASS: Experimental Analysis
29	RESEARCH METHOD: Formal experiment/multiple variable
36	REPORT TITLE: The Effect of Simulator Fidelity on Engine Failure Training in the KC-135 Aircraft.
37	REPORT AUTHOR: Deberg, O.H.; McFarland, B.P.; Showalter, T.W.
38	REPORT DATE: 76/04/00
40	ORIGINATING ACTIVITY: Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio
52	PUBLISHEP/SPONSOR: American Institute of Aeronautics and Astronautics, New York, N.Y.
56	TYPE OF PUBLICATION: Presentation

Key Number	
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 026
7 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Johnson, N.A.; Foster, M. Pilotage Navigation Utilizing a Night-Vision System. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, TM 6-77, February, 1977.

5 ABSTRACT:

PURPOSE: The purpose of this report was to determine how field of view and display medium affect a flight-crew member's ability to perform pilotage navigation with a forward looking infrared (FLIR) night-vision system.

METHOD: The six subjects were all Cobra qualified aviators averaging 4.5 years rated and 1466 hours of rotary-wing experience. The test aircraft was an AH-1G helicopter with turret-mounted FLIR, helmet-mounted display (HMD), and panel-mounted display (PMD). The experimental design incorporated, for each pilot, these two modes of viewing and three fields of view (FOV) (15x20, 30x40, and 45x60 degrees). Two nap-of-the-earth (NOE) courses were flown. Conditions were counter-balanced to control for practice effects and terrain variations. Each subject was given one week of training on the operation of the FLIR on courses separate from the 8km test course. Three types of measures were analyzed: time to complete mission; total errors committed; and number of sensor slews.

RESULTS: For time, there were no statistically significant differences between displays or FOV. There did exist a significant display by FOV interaction (F=3.87, p .LT. .06). A Tukey post hoc test indicated a wide FOV was more effective for NOE navigation purposes than narrow and medium FOVs. Because nearly all flights took over 20 minutes, with considerable hovering, the power required left very little power margin, and excessive fuel was burned. Total errors were significant for FOV (p .LT. 01), again showing the superiority of the wide FOV. As for sensor slews, HMD was slewed more than PMD (p .LT. .001), and the narrower the FOV, the greater the slew (p .LT. .001).

6 AUTHOR'S CONCLUSIONS:

"The data indicate that a wide FOV, on the order of 45 (degrees) vertical x 60 (degrees) horizontal, is more effective for NOE navigation purposes than narrower FOV's."

Key Number	
7	EVALUATION: This report is uncomplicated and easy to read. The results and conclusions are important to HMD and PMD use. However, the implications for training inexperienced pilots are not known.
10	AUTHOR'S RESEARCH SUGGESTIONS: Evaluation of an addition of a DOPPLER radar to the systems used in this study.
14	DEPENDENT VARIABLES: Time to complete mission; total navigational errors; number of sensor slews.
15	INDEPENDENT VARIABLES: Size of field of view; helmet- versus panel-mounted display
16	MEASUREMENT/STATISTICAL METHODS: ANOVA; an unspecified Tukey post hoc test
22	SYSTEM/CLASS: Helmet-mounted display; panel-mounted display
23	SUBJECT POOL: Cobra qualified aviators
24	NUMBER OF PAGES: 0017
25	NUMBER OF REFERENCES: 0004
28	RESEARCH CLASS: Experimental Analysis
29	RESEARCH METHOD: Formal experiment/multiple variable
36	REPORT TITLE: Pilotage Navigation Utilizing a Night-Vision System
37	REPORT AUTHOR: Johnson, N.A.; Foster, M.
38	REPORT DATE: 77/02/00
40	ORIGINATING ACTIVITY: U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

Key Number

48 REPORT NUMBER:
Technical Memorandum 6-77

52 PUBLISHER/SPONSOR:
U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

56 TYPE OF PUBLICATION:
Technical memorandum

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 027
9 January 1978

Key Number

1 ACCESSION NUMBER: AD-A008 201

4 CITATION:
Meyer, R.P.; Laveson, J.I.; Weissman, N.S.; Eddowes, E.E. Behavioral Taxonomy of Undergraduate Pilot Training Tasks and Skills: Taxonomy Refinement, Validation and Operations. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-74-33(3), December, 1974.

5 ABSTRACT:
PURPOSE: The purpose of the report was to determine certain fundamental flying skills taught during Undergraduate Pilot Training (UPT) and to develop a taxonomic structure which describes an orderly relationship between the tasks and skills studied.
SUMMARY: This article reported on the second phase of a program to develop a behavioral taxonomy of UPT tasks and skills. In Phase 1 a surface analysis of 14 flight maneuvers was conducted, focusing on three types of transitional flying tasks: (a) fundamental transitions--a change from one steady state to another; (b) composite transitions--combinations of two or more fundamental transitions in a procedural sequence; and (c) continuous transitions--combinations of any number of fundamental and composite transitions in rapid succession. Each task was divided into sequences and each sequence into cues, mental action, and motor action elements. In addition, Phase 1 established rules by which the taxonomy and classification system was built. Phase 2 focused on a surface analysis of 22 additional flight maneuvers and an improvement of classification rules. An alphanumeric code was established which was compatible with both the surface analysis and classification rules. Formalization of rules, instructions, and surface analysis into a complete package was called the UPT Maneuver Analysis Kit (MAK). A taxonomic cubic structure was designed with cues, motor actions, and mental actions serving respectively as the vertical, horizontal, and depth axes. This structure was refined and validated by a study in which flying training personnel used the system to classify sample tasks. Eighty-two per cent agreement among validation subject responses indicated that the application of taxonomy rules to the surface analysis was successful. Subject responses to a questionnaire indicated that the task could be completed, although it was difficult and time consuming. In order to separate task skills into consistent categories, a

Key Number

classification hierarchy was then established. All data were noted on individual cards and a 4x8ft matrix board was devised to hold the sorted cards. The matrix system provided a means for a simple data retrieval system. The operation of the matrix system was illustrated by several examples. Lengthy appendices provide details of the MAK, validation data, and classification systems.

6 AUTHOR'S CONCLUSIONS:
The identification of which skill groups were associated with which types of tasks provided the basic information necessary to develop a training program based on skill requirements rather than a maneuver oriented program. The classification system was shown to be possible and it could be executed by personnel familiar with flying terminology but not trained in task analysis.

7 EVALUATION:
The glossary of terms, and presentation of surface task analyses and other information in appendices, add clarity to the report. The classification system could be valuable in task analyses basic to flight training. The focus on component skills rather than complete tasks opens up possibilities for low fidelity and part-task trainers to teach component skills which can be generalized to and integrated into tasks which per se could not be taught in such devices.

24 NUMBER OF PAGES:
0213

25 NUMBER OF REFERENCES:
0009

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Organization

33 SUPPLEMENTARY NOTES:
"This report consists of 4 volumes." (Only volume 3 in this abstract.)

36 REPORT TITLE:
Behavioral Taxonomy of Undergraduate Pilot Training Tasks and Skills: Taxonomy Refinement, Validation and Operations

37 REPORT AUTHOR:
Meyer, R.P.; Laveson, J.I.; Weissman, N.S.; Eddowes, E.E.

Key Number

38 REPORT DATE:
74/12/00

40 ORIGINATING ACTIVITY:
Design Plus, 9955 Warshire Drive, St. Louis, Missouri

44 CONTRACT/PROJECT/TASK:
F41609-73-C-0040/62703F/11230217

48 REPORT NUMBER:
AFHRL-TR-74-33(3)

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 028
9 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Kennedy, R.S.; Smith, R.L.; Wulfeck, J.W.; Queen, J.E.; Burger, W.J. Optimization of Control Stick Dynamics and Prediction Span Parameters in a Predictor Display Study of a Jet Aircraft Carrier Landing Simulation. Pacific Missile Test Center, Point Mugu, California, TP-75-55, 15 October, 1975.

5 ABSTRACT:
PURPOSE: Two experiments are reported, both concerned with the utility of a predictor display (PD) in landing jet aircraft. Experiment 1 investigated the effects of prediction span and control stick assumptions on aircraft control. Experiment 2 sought to validate "the previously demonstrated advantages of the PDs . . . for a group of aviators who flew daily, but were not recently experienced in the F-4 aircraft."
METHOD: Experiment 1 used an unstated number of Ss who were Air Force or Navy ROTC students, and who has previously performed the same simulated landing tasks. Each S completed 100 total trials during two 1-hour sessions. In each trial the S flew a T-37 simulator starting from level flight, along a glideslope beginning at 500 ft and with a 1.25-mile ground range. A factorial design was used with three levels of PD spaces (10, 20, and 30 seconds) and three levels of stick assumptions (0, 1, and 3 seconds before return to null position). An additional condition had no PD and no stick level requirement. It was not stated whether each S flew all combinations of conditions or different Ss were used for each set of variables. Performance was measured as the integral altitude error over a trial. In experiment 2, 6 "novice" and 6 "experienced" Naval aviators were used, all but two of whom were experienced pilots with considerable carrier landing experience. The difference between the groups was that the experienced Ss were current in F-4 aircraft and only one novice S had F-4 carrier landing experience. Three displays were used: PD, baseline (BL), and glideslope tunnel (GT). Each S participated in 36 trials with each display mode, the order of modes varying with each S but each mode occurring first, second, or third an equal number of times. During each trial of approximately 1 minute duration the S executed a simulator night carrier landing approach. Performance was measured as departures in heading, azimuth, and sink rate from a 3.5 degree glideslope with a defined target.

Key Number

RESULTS: Experiment 1: With the exception of the 20-second prediction span, 1-second stick assumption condition, "all conditions showed an increase in performance from the first to the second test session. All predictor instrument conditions showed considerably better performance than did the control condition . . . (and) there were no significant differences between the three prediction spans or the three stick assumptions . . . (also) performance on the control condition was significantly worse than any one of the test conditions." In experiment 2, BL scores were poorest for both experienced and novice pilots, and PD scores best. Novice Ss who received BL display last were superior on these scores to novice Ss who received BL display first or second. As for experienced vs. novice S comparisons, no significant difference was reported for PD, but experienced Ss were superior for BL (p .LT. .05) and GT (p .LT. .001).

7 EVALUATION:

It is possible that the results of these studies actually support the enthusiastic statements by the authors regarding "unlimited" potential for PD applications. However, the reported results can be questioned for a number of reasons. No statistical analyses were reported or even alluded to in experiment 1, and the five chi square analyses reported in experiment 2 should be questioned: The ps reported cannot be obtained with only 12 Ss. It appears that these tests were run on scores, not counts of Ss, and hence are meaningless. If the Kolomogorov/Smirnov and Mann-Whitney U tests were similarly misapplied, what was really found in experiment 2 cannot be known. The poor reporting leaves many more questions--how many Ss were used in experiment 1? What was the justification for claiming no differences for PD-stick assumption conditions, but reporting a difference for control conditions? How can it be said, "In general, the Experienced Group (in experiment 2) had almost twice the aviation experience as the Novice Group" when means for the former were 8 years as pilots, 190 day and 97 night carrier landings, and 13.5 months since last arrested carrier landing. Compare with novice means of 5 years as pilots, 131 day and 49 night carrier landings, and 17.5 months since last arrested carrier landing. The latter group can be considered novices only in that only one had F-4 experience. (He also had 350 day and 150 night carrier landings!) In fact, the relatively low means given above for the novice group were due primarily to only 2 Ss. Many other issues could be raised, but the point is this: Much was made of the lack of a difference between "experienced" and "novice" pilots using PD, supposedly implying a high value for PD in training truly novice pilots. However, only two pilots inexperienced in carrier landings

Key Number

were used, and their data were confounded with those of four experienced ones. Hence, the scope of training value of PD is unknown.

8 COMMENTS:
The title used in the citation was the one appearing on the Report Documentation Page. The cover for the report gives the title as: "Two Studies of Predictor Displays for Jet Aircraft Landings: 1. Optimization of Control Stick Dynamics and Prediction Span Paramaters; 2. A Comparison Between Experienced and Novice Navy F-4 Pilot Simulated Landing Performances."

14 DEPENDENT VARIABLES:
Errors in heading; errors in azimuth; errors in sink rate; integral altitude error

15 INDEPENDENT VARIABLES:
Prediction display span; visual display type; joystick assumption

16 MEASUREMENT/STATISTICAL METHODS:
Chi square; Mann-Whitney U test; Kolmogorov/Smirnov test

22 SYSTEM/CLASS:
Predictor display; baseline display; glideslope tunnel display

23 SUBJECT POOL:
Air Force and Navy ROTC students in experiment 1; experienced Naval pilots in experiment 2

24 NUMBER OF PAGES:
0026

25 NUMBER OF REFERENCES:
0006

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Optimization of Control Stick Dynamics and Prediction Span Parameters in a Predictor Display Study of a Jet Aircraft Carrier Landing Simulation

Key Number

37 REPORT AUTHOR:
Kennedy, R.S.; Smith, R.L.; Wulfeck, J.W.; Queen, J.E.; Burger, W.J.

38 REPORT DATE:
75/10/15

40 ORIGINATING ACTIVITY:
Pacific Missile Test Center, Point Mugu, California

44 CONTRACT/PROJECT/TASK:
AIRTASK #A3400000/054B/4F55-525-400

48 REPORT NUMBER:
TP-75-55

52 PUBLISHER/SPONSOR:
Pacific Missile Test Center, Point Mugu, California

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 029
9 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Gibino, O.J. B-1 Aircrewmember Training Equipment Systems Analysis Study, Phase 1. Flight Simulator Branch, Wright-Patterson Air Force Base, Ohio, Technical Memorandum ASD/ENCT 72-1, 31 January, 1972.

5 ABSTRACT:
PURPOSE: The purpose of this systems analysis was to compare training costs of various configurations of locations and concentrations of training equipment.
SUMMARY: This preliminary report was broken down into six main areas: (a) description of personnel flow and simulators in the FB-111 program; (b) centralization vs. decentralization of B-1 crew training equipment; (c) types and costs of different B-1 crew training equipment; (d) B-1 system alternatives and costs; (e) special mission simulator considerations; and (f) conclusions and recommendations. The present flow of personnel being trained from Mather AFB through Plattsburg AFB and on Pease AFB, was broken down by hours, weeks, and/or months required for pilot and navigator training. The centralization vs. decentralization discussion defined four levels of centralization of equipment but focused on SAC centralized training bases. Advantages of the SAC system included more capability; less procurement funding; centralized SAC control; and lower operating costs. Disadvantages were the inconvenience and cost of temporary duty (TDY) and loss of control of training by local commanders. Discussions of types and costs of various B-1 crew training equipment started with a full crew station mock-up constructed of plywood, photographs, and drawings (to be used only for familiarization) at a unit cost of $40,000 and continued to a full mission simulator (MS) or avionics simulator (AS) for a prototype unit cost of 16M and 12M, respectively. B-1 system alternatives were compared to a baseline configuration which would locate an MS at every base with estimated costs ranging from 100M for 7 bases to 207M for 14 bases. Included in these cost estimates were 1 to 3 AS devices for Avionics Upgrade Training programs. Alternative 1 would replace AS with an Avionics Procedures Trainer at a savings of 9.5M for 7 bases and 18.1M for 14 bases. Alternative 2 further replaced MSs at field locations with flight simulators, thus restricting MSs to combat crew training squadron (CCTS) locations which would require 1-2

Key Number

days TDY per crew 4 times a year. The savings over baseline for 7 and 14 bases were estimated to be 20M and 51M, respectively. A third alternative would place all training equipment except that needed for Avionics Upgrade Training at a central CCTS base. TDY would still be four times a year but for 2-3 days per crew. Estimated savings over baseline for 7 and 14 bases would be 30.5M and 76.7M, respectively. Seven special mission simulator considerations were identified but none discussed. They were: (a) the possible impracticality of locating high-resolution simulation of radar landmass and infrared displays throughout the continental U.S. (CONUS); (b) the desirability of simulation outside CONUS; (c) the acceptability of landmass simulation without adequate maps; (d) the acceptability of corridors as opposed to free flight; (e) the necessary geographic simulation for low light level TV; (f) the question of whether "out-the-window" visual display was necessary; and (g) whether there should be a master site to track modifications, compile computer programs, and accomplish in-house software modifications.

6 AUTHOR'S CONCLUSIONS:
It is implied that viable crew training alternatives exist, and that such alternatives offer more training capability for less money because: (a) less expensive training equipment can be substituted for mission simulators in areas such as procedural training; (b) centralized systems can time-share certain equipment; (c) devices are often not used to full capacity at field locations.

7 EVALUATION:
The author judiciously focused on pertinent results of analyses in the text, while providing details of analyses in the appendix. The report is thus easy to read, and with appropriate use of appended material, easy to understand. The cost estimates clearly show the advantages of centralization of training devices from the standpoint of expense.

10 AUTHOR'S RESEARCH SUGGESTIONS:
The author recommended that a funded follow-on study be conducted that would: involve and elicit assistance and cooperation from SAC and ATC; address ATC's training program; and re-examine the total SAC training problem.

14 DEPENDENT VARIABLES:
Cost of aircrew training

15 INDEPENDENT VARIABLES:
Centralization vs. decentralization of facilities

Key Number	
22	SYSTEM/CLASS: Mission simulators
24	NUMBER OF PAGES: 0032
25	NUMBER OF REFERENCES: 0004
28	RESEARCH CLASS: Logical Study
29	RESEARCH METHOD: Logical analysis and description
36	REPORT TITLE: B-1 Aircrewmember Training Equipment Systems Analysis Study, Phase 1.
37	REPORT AUTHOR: Gibino, O.J.
38	REPORT DATE: 72/01/31
40	ORIGINATING ACTIVITY: Flight Simulator Branch, Wright-Patterson Air Force Base, Ohio
48	REPORT NUMBER: Technical Memorandum ASD/ENCT 72-1
52	PUBLISHER/SPONSOR: Wright-Patterson Air Force Base, Ohio
56	TYPE OF PUBLICATION: Technical memorandum
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 030
9 January 1978

Key Number

1 ACCESSION NUMBER: AD-A015 835

4 CITATION:
Cream, B.W.; Lambertson, D.C. Functional Integrated Systems Trainer: Technical Design and Operation. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-75-6(2), June, 1975.

5 ABSTRACT:
PURPOSE: The overall project, a part of which is the subject of the report, had as its purpose the design of a low-cost, effective individual and crew coordination trainer for the AC-130H Gunship's fire control team. In developing the design, task analyses were conducted and cost/benefit relationships of various degrees of simulation of each task were determined. Part 1 of this report described the analyses and evaluation of the resulting trainer and discussed applications of design and utilization principles to other systems. The purpose of the present report, Part 2, was to describe in detail the construction and operation of the resulting device.
SUMMARY: The description of the device included: the operator console; the infrared (IR) student console; the low light level TV student console; the black crow/electronic warfare operator (BC/EWO) student console; and the fire control student console. For each system, photographs and line drawings are provided with keys to extensive tables that identify components and their functions. Operations are then described for the following systems: IR; fire control; fire control display; BC/EWO; navigation; and interphone.

7 EVALUATION:
The extensive use of figures and tables, correspondingly keyed, makes the descriptions of the device subsystems easy to follow. Specific schematic and signal flow diagrams are beyond the scope of this report, but are referenced therein as TO.43E-2-2-1, FIST (for Functional Integrated Systems Trainer) Operation and Maintenance Manual, 1 December 1974. (This manual is also a product of the overall project.)

12 CROSS REFERENCES:
AFHRL-TR-75-6(1), Part 1 of this report

22 SYSTEM/CLASS:
Integrated systems trainer for the AC-130H

Key Number	
24	NUMBER OF PAGES: 0057
25	NUMBER OF REFERENCES: 0000
28	RESEARCH CLASS: Status Study
29	RESEARCH METHOD: Description
33	SUPPLEMENTARY NOTES: The effort was supported by program element 61101F, In-House Laboratory Independent Research Funds
36	REPORT TITLE: Functional Integrated Systems Trainer: Technical Design and Operation
37	REPORT AUTHOR: Cream, B.W.; Lambertson, D.C.
38	REPORT DATE: 75/06/00
40	ORIGINATING ACTIVITY: Systems Research Laboratories, Inc., 2800 Indian Ripple Road, Dayton, Ohio
44	CONTRACT/PROJECT/TASK: F33615-73-C-4134/61101F/ILIR0005
48	REPORT NUMBER: AFHRL-TR-75-6(2)
52	PUBLISHER/SPONSOR: Air Force Systems Command, Brooks Air Force Base, Texas
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:

Key Number

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 031
9 January 1978

Key Number

1 ACCESSION NUMBER: AD-A040 551

4 CITATION:
Cyrus, M.L. Method for Compensating Transport Lags in Computer Image Generation Visual Displays for Flight Simulation. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-77-6, March, 1977.

5 ABSTRACT:
PURPOSE: A major problem in flight simulation is the integration of visual, motion, and aerodynamic subsystems. A subproblem is the visual subsystem compensation to the flight system. With a Computer Image Generation (CIG) system a lag of 50 to 100 milliseconds must be compensated to provide a smooth output void of flutter effects. The purpose of this paper was to introduce a general method of providing such compensation.
SUMMARY: Four basic assumptions were made: (a) iteration interval of both flight and visual systems was the same (small) quantity; (b) position, velocity, and acceleration data were current; (c) the flight output was accurate; and (d) the sequence of future accelerations and the position, velocity, and acceleration at any point in time served to define the entire position and velocity history forward. An integration model was then established, using an arbitrary variable V for position, V' for velocity, and V" for acceleration where V' and V" are first and second order differentiations, respectively, with respect to time. The generalizability of the model is due to its capability of adjusting the CIG transport compensation smoothness parameter for each degree of freedom of the aircraft. A mathematical solution was derived since the integration technique was deterministic, and the linear combinations vector was solved as the product of two matrices and the acceleration vector. The remaining structure on the space is defined by a low-pass filter requirement, and a Butterworth low-pass filter was chosen as it provided smooth magnitude and phase response. It was concluded that this technique can be extended to combinations of transport and phase lag. Off-line evaluations are also possible of candidate solutions to the overall integration problem involving differing iteration rates, servo characteristics, etc.

7 EVALUATION:
The article can be followed easily by one familiar with the technical aspects of CIG compensation to device motion and

Key Number

aerodynamic characteristics. The model is straightforward and the mathematics are standard, though technical.

14 DEPENDENT VARIABLES:
Compensation of computer image generation to simulator motion and aerodynamics

22 SYSTEM/CLASS:
Computer image generation

24 NUMBER OF PAGES:
0010

25 NUMBER OF REFERENCES:
0004

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Mathematical derivation

36 REPORT TITLE:
Method for Compensating Transport Lags in Computer Image Generation Visual Displays for Flight Simulation

37 REPORT AUTHOR:
Cyrus, M.L.

38 REPORT DATE:
77/03/00

40 ORIGINATING ACTIVITY:
Flying Training Division, Williams Air Force Base, Arizona

44 CONTRACT/PROJECT/TASK:
62703F

48 REPORT NUMBER:
AFHRL-TR-77-6

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

Key Number	
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 032
10 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Gibbs, R.G. Procedures Generation Program (PGP) Applications to Commercial Airlines. McDonnell Douglas Technical Services Co., Houston Aeronautics Division, Crew Procedures Development Techniques Design Note No. 10, 20 December, 1974

5 ABSTRACT:
PURPOSE: The purpose of the report was to determine the potential application of new technology resulting from the Procedures Generation Program (PGP) to current and future airline pilot training.
SUMMARY: The PGP is an automated crew procedures generation and performance system which consists of a digital program that translates Shuttle Procedures Simulator data inputs into crew procedures, difference procedures, and crew and vehicle performance data. An evaluation of the capability to monitor, record, and output simulator run data focused on automated procedures development and crew training performance evaluation. The PGP's automated crew procedures generation capability was not considered useful for commercial airlines because most crew procedures are developed by the airplane manufacturer and are generally accepted by the airlines. The PGP's ability to create individual procedures for each pilot is of no interest to airlines because they rely on standardization as a means to safe operation. The PGP crew performance evaluation capability already exists in airline simulators. The PGP's performance data capability, although not useful at the present time, would permit a comparison of simulator versus airplane data should airplane airborne data reporting and recording systems be developed. Preliminary results of cost effectiveness studies show that cost effective use of the PGP would not be possible if it is added to existing simulator fleets, but may be possible following procurement of next generation simulators.

6 AUTHOR'S CONCLUSIONS:
"The PGP capabilities . . . do not represent new or improved crew training concepts or technology." "Potential for beneficial application of this (individualized procedures) feature would seem to lie with the airplane and simulator manufacturers, if it can be used during that period when flight crew procedures are initially developed." "Ultimate benefit, in terms of improved training and evaluation, will depend not

Key Number

only on a workable type of PGP, but also on a commitment by the user (airline management) to this type of system."

7 EVALUATION:
This study was well presented but its main value in simulation design rests in its recognition of needed research as suggested by the author.

10 AUTHOR'S RESEARCH SUGGESTIONS:
"Continued development of the PGP should be undertaken with emphasis upon studies of transfer-of-training, adaptive training programs, automated training capability, individualized training programs." "The inclusion of PGP capabilities in future simulator design should be investigated after the PGP reaches a fully operational state. Detailed cost effectiveness evaluations of a PGP capability as an integral part of a new simulator complex should be accomplished."

22 SYSTEM/CLASS:
Procedures generation program

24 NUMBER OF PAGES:
0015

25 NUMBER OF REFERENCES:
0006

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Procedures Generation Program (PGP) Applications to Commercial Airlines

37 REPORT AUTHOR:
Gibbs, R.G.

38 REPORT DATE:
74/12/20

40 ORIGINATING ACTIVITY:
United Airlines

44 CONTRACT/PROJECT/TASK:
NAS9-13660

Key Number	
49	OTHER REPORT NUMBER: Design Note No. 10
52	PUBLISHER/SPONSOR: Houston Astronautics Division, McDonnell Douglas Technical Services Company
56	TYPE OF PUBLICATION: Technical note
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 033
10 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Gum, D.R.; Knoop, P.A.; Basinger, J.D.; Guterman, I.M.; Foley, W.L. Development of an Advanced Training Research Simulation System. PROCEEDINGS: PSYCHOLOGY IN THE AIR FORCE, 3RD ANNUAL SYMPOSIUM, U.S. Air Force Academy, 95-104, April, 1972.

5 ABSTRACT:
PURPOSE: The purpose of this report was to describe an advanced research flight simulation system.
SUMMARY: The Advanced Simulator for Undergraduate Pilot Training (ASUPT) consists of: (a) two basic T-37B simulators; (b) two wide-angle infinity visual displays; and (c) a shared visual computer image generator (CIG). The mathematical modeling is complete with high fidelity capability in most areas which can be systematically degraded by a researcher for studies of transfer of training as a function of fidelity. Motion and force simulation is accomplished through a combination of a six-degree-of-freedom synergistic motion system and a sustained g seat. The computer system for both simulators is composed of a single SYSTEMS 86 central processor unit and the SYSTEMS 86 Real Time Monitor, a disc-oriented multiprogramming monitor system providing 64 software priority levels for control of both foreground and background tasks. There are six stations for the two simulators: one conventional station, one combined advanced/conventional station, two in-cockpit instructor stations, and two in-cockpit student stations. Seven Advanced Instructional Provisions are included to provide standardization and a basis for evaluating the effect upon training of automated instruction, student-directed training, and adaptive training. The visual system consists of a mosaicked in-line display driven by a multi-channel CIG system. Seven pentagon-shaped display channels are mosaicked together to form a partial dodecahedron shell surrounding the cockpit. Each channel is an in-line display in which the image appears to originate at infinity. The need to use high-brightness cathode ray tubes (CRTs) results in a monochrome display. The CRTs are 36 inches in diameter with a 24-inch radius faceplate. The CIG system generates a video signal similar to that of a television camera. The image consists of surface patterns or objects formed by planes of different brightness levels bounded by straight lines or "edges." A simulated visual environment in numerical form is stored on a magnetic disc; thus, it can be amended easily. The CIG

Key Number

system's edge format of storing, retrieving, and transforming is converted into a digital scan line format. The brightness level of each part of the scan line is in digital form and is converted into a video signal by a high-speed digital-to-analog computer. Edge smoothing and continuous shading of surfaces are employed to improve image quality.

7 EVALUATION:
The ASUPT was described well and its potential as a training research device clearly indicated.

22 SYSTEM/CLASS:
Advanced Simulator for Undergraduate Pilot Training (ASUPT)

24 NUMBER OF PAGES:
0017

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

36 REPORT TITLE:
Development of an Advanced Training Research Simulation System

37 REPORT AUTHOR:
Gum, D.R.; Knoop, P.A.; Basinger, J.D.; Guterman, I.M.; Foley, W.L.

38 REPORT DATE:
00/00/00

40 ORIGINATING ACTIVITY:
Air Force Human Resources Laboratory

52 PUBLISHER/SPONSOR:
U.S. Air Force Academy, Colorado, Springs, Colorado

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

Key Number	
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 034
10 January 1978

Key Number

1 ACCESSION NUMBER: AD-A035 682

4 CITATION:
Tyler, D.M.; McFadden, R.W.; Eddowes, E.E.; Fuller, R.R. Investigation of Diagnostic, Error Detector, and Self-Taught Instructional Strategies for Flight Simulator Programs. Flying Training Division, Williams Air Force Base, Arizona, AFHRL-TR-76-65, October, 1976.

5 ABSTRACT:
PURPOSE: The purpose of the report was to determine if there were significant differences between diagnostic, error detector, and self-taught instructional strategies for a T-40 flight simulator program.
METHOD: Three experienced instructor pilots (IPs) were given training and allowed to practice standardized directions for each of the strategies. The diagnostic strategy involved the detection of deviation from desired parameters and required procedures with timely instructions on correction techniques. The student received feedback from the IP as well as through aircraft instruments. The error detector strategy involved detection and acknowledgment of errors by the IP, but excluded error analysis and description of why they occurred and how they should be corrected. Feedback was immediate but limited. The self-taught strategy involved one-time only instruction of maneuvers by the IP, after which the student practiced alone. The IP provided no verbal feedback. Twenty-seven Air Force officers were randomly assigned to three strategy groups of nine each. Ss studied and were tested on a pre-training guide. After pretraining, Ss flew four 50-minute T-40 sorties. The first sortie was to teach straight and level flight, left turns, and right turns; the second sortie was to teach constant airspeed climbs and descents; the third sortie was used for practice. The fourth sortie was the criterion sortie composed of continuous testing of all maneuvers, first under the normal conditions of the first three sorties, and then under two different task load conditions. One load factor was a change in the center of gravity from normal to full forward. A second load factor was a change in rough air from zero to maximum turbulence.
RESULTS: There were no significant differences among strategies. Significant main effects of task load conditions over all maneuvers were noted. Generally, Ss did poorly with the full-forward center of gravity, and even more poorly when they flew with maximum turbulence.

Key Number

7 EVALUATION:
This study was well designed and clearly reported except that it was uncertain whether each IP used each training technique with various subjects. If so, possible IP-technique interactions were avoided.

10 AUTHOR'S RESEARCH SUGGESTIONS:
A subsequent study should be conducted to test empirically a computer controlled and assisted simulator sortie as sketched by the authors.

14 DEPENDENT VARIABLES:
Student pilot performance

15 INDEPENDENT VARIABLES:
Type of instructional strategy (diagnostic, error detector, self-taught) and task load condition (no task loading, a change in center of gravity from normal to full forward, a change in air turbulence from zero to maximum).

16 MEASUREMENT/STATISTICAL METHODS:
Split pilot factorial analyses of variance; t statistic; Spearman rank-order correlation coefficient

20 SYSTEM/CLASS:
T-40 flight simulator

23 SUBJECT POOL:
Air Force officers awaiting entry into undergraduate pilot training

24 NUMBER OF PAGES:
0208

25 NUMBER OF REFERENCES:
0013

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Investigation of Diagnostic, Error Detector, and Self-Taught Instructional Strategies for Flight Simulator Programs.

37 REPORT AUTHOR:
Tyler, D.M.; McFadden, R.W.; Eddowes, E.E.; Fuller, R.R.

Key Number	
38	REPORT DATE: 76/10/00
40	ORIGINATING ACTIVITY: Flying Training Division, Williams Air Force Base, Arizona
44	CONTRACT/PROJECT/TASK: 62703F/11230220
48	REPORT NUMBER: AFHRL-TR-76-65
52	PUBLISHER/SPONSOR: Air Force Systems Command, Brooks Air Force Base, Texas
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 035
13 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Prophet, W.W. Performance Measurement in Helicopter Training and Operations. Human Resources Research Organization, Alexandria, Virginia, HumRRO-PP-10-72, April, 1972.

5 ABSTRACT:

PURPOSE: The purpose of the report was to review the development of performance measurement systems in helicopter training and operations.

SUMMARY: Research has emphasized measures of achievement during training and the extent to which these measures predict future performance. In a series of studies, Greer, Smith, and Hatfield developed a group of helicopter flight performance checklists called the Pilot Performance Description Record (PPDR). Each maneuver was carefully analyzed and items or scales describing specific pilot and aircraft behaviors were developed. Where feasible, objective indices such as airspeed and altitude were used. Similar instruments were developed by Prophet and Jolley for fixed wing flight measurement. A study of the PPDR's effectiveness at the Army's Primary Helicopter School showed that checkride grades derived from the PPDR correlated significantly with training grades, while checkride grades assigned under the existing subjective system did not correlate. The PPDR was shown to be useful in that it: (a) provided standardization and objectivity in performance measurement; (b) informed the student as to the performance objectives he should achieve and items on which he would be measured; (c) provided detailed postflight feedback to the student; (d) provided items or scales which could be used as input to automatic data processing by which the performance of large groups could be summarized; (e) allowed examination of individual critical maneuvers; and (f) allowed the functioning of instructors and checkpilots to be examined and needed corrective action to be taken. A series of studies by Caro investigated the effects of prior knowledge on checkride evaluations. In one group, instructors from within the same instructional flight graded students at checkride time. These evaluators knew who the student's instructor had been and what type of student that instructor normally produced. In another group, instructors from outside the instructional flight graded the checkrides. Those latter checkrides showed negligible correlation between instructor evaluation and checkride grade, whereas those graded from within the instructing

Key Number

flight showed substantial correlation. Caro concluded that prior knowledge of the student, rather than similarity of evaluation standards, may have accounted for the high correlations of the latter group. Recent work has dealt with multiple regression approaches to predicting student performance and has resulted in the development of a computerized data bank for predicting a variety of aviator performances. A need was shown for "predictor variables to account for aspects of operational performance variance independent of training performance, that is, motivational factors." A study by Caro, Isley and Jolley reporting on the predictability of subsequent flight performance from performance on a captive helicopter device raised questions regarding the quality or kind of data from which multiple predictions are made. One task, precision hover, was easily mastered by students but difficult for experienced pilots, who used different visual cues. Although this task lacked validity according to experienced pilots, it proved very effective in predicting performance at all stages. Contradictory findings in studies dealing with prediction of subsequent performance from early flight performance were analyzed. It was found that early flight measures showing substantial correlation with later flight measures had been based upon objective indices, whereas those which did not correlate were based upon subjective evaluations. Future gains in performance measurement effectiveness and efficiency were seen to rest on automated measurement systems, such as the Army's Synthetic Flight Training System undergoing testing at the time of this paper's writing.

7 EVALUATION:
The article is a well-written informal discourse on the development of flight performance measurement systems. The report shows clearly the value of objective measures in standardization of evaluation and for valid indices of performance.

14 DEPENDENT VARIABLES:
Validity of aircraft performance measures

15 INDEPENDENT VARIABLES:
Subjective vs. objective measures

16 MEASUREMENT/STATISTICAL METHODS:
Pearson r

24 NUMBER OF PAGES:
0015

25 NUMBER OF REFERENCES:
0013

Key Number	
28	RESEARCH CLASS: Status Study
29	RESEARCH METHOD: Historical
33	SUPPLEMENTARY NOTES: Also presented as a paper at the Annual Convention of the American Psychological Association, Washington, D.C., September, 1971.
36	REPORT TITLE: Performance Measurement in Helicopter Training and Operations
37	REPORT AUTHOR: Prophet, W.W.
38	REPORT DATE: 72/04/00
40	ORIGINATING ACTIVITY: Human Resources Research Organization, Fort Rucker, Alabama
44	CONTRACT/PROJECT/TASK: DAHC 19-70-C-0012
49	OTHER REPORT NUMBER: HumRRO-PP-10-72
52	PUBLISHER/SPONSOR: Human Resources Research Organization, Alexandria, Virginia
56	TYPE OF PUBLICATION: Professional paper
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 036
13 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Caro, P.W.; Hall, E.R.; Brown, G.E., Jr. Design and Procurement Bases for Coast Guard Aircraft Simulators. Human Resources Research Organization, Alexandria, Virginia, Technical Report 69-103, December, 1969.

5 ABSTRACT:
PURPOSE: The purpose of this report was to determine the need for and projected costs of aircraft simulators for the Coast Guard, and the projected savings deriving from simulator use. SUMMARY: The article reported on part of a project to determine functional requirements for training devices. The Variable Cockpit Training System (VCTS) was designed, consisting of "a computer complex with supporting peripheral equipment and computer programs to which may be added up to two cockpit modules representing various search and rescue aircraft." Two configurations of the VCTS--rotary wing and fixed wing--were included. The characteristics of the VCTS were given in a Qualitative Material Requirement which constituted an appendix to the report. The VCTS was predicted to result in savings of fuel, maintenance, and personnel costs by eliminating the operation of aircraft for training purposes and freeing them for other missions. If the VCTS were used for rotary wing transition and qualification training only, an annual savings of $477,663 was projected. If the rotary wing configuration were also used for proficiency training, the savings would increase to $2,370,452. The $477,663 savings resulting from VCTS use in rotary wing transition and qualification training would offset the cost of its acquisition and the building to house it in about 5.5 years. The corresponding time if the VCTS were also used for rotary wing proficiency training was 1.1 years. Once the rotary wing configuration had been procured, the savings in VCTS use for fixed wing transition and qualification training was estimated at $169,015 per year. Additional use of the fixed wing configuration in proficiency training was estimated to increase savings to $1,277,931. Thirteen years would be required to offset acquisition costs of the fixed wing configuration if used solely for transition and qualification training. Its additional use in proficiency training would result in an offsetting of costs in about 1.7 years. The economic advantage of including the equipment's use in proficiency training was clearly noted. A procurement plan was designed which identified funding requirements by

Key Number

fiscal year and projected the occurrence of procurement milestones.

7 EVALUATION:
The article is well-written and helpfully illustrated by charts and tables. The cost reductions in using the VCTS for various training functions were well documented.

8 COMMENTS:
No references were listed as such, but footnotes identify 13 sources of information as well as bases for cost-related computations.

14 DEPENDENT VARIABLES:
Cost effective pilot training

22 SYSTEM/CLASS:
Helicopter flight simulator/Variable Cockpit Training System

24 NUMBER OF PAGES:
0050

25 NUMBER OF REFERENCES:
0013

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Logical analysis and description

36 REPORT TITLE:
Design and Procurement Bases for Coast Guard Aircraft Simulators

37 REPORT AUTHOR:
Caro, P.W.; Hall, E.R.; Brown, G.E., Jr.

38 REPORT DATE:
69/12/00

40 ORIGINATING ACTIVITY:
Human Resources Research Organization, Fort Rucker, Alabama

44 CONTRACT/PROJECT/TASK:
DOT-CG-92556-A

49 OTHER REPORT NUMBER:
HumRRO Technical Report 69-103

036-2

Key Number

52 PUBLISHER/SPONSOR:
Human Resources Research Organization, Alexandria, Virginia

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 037
13 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Daniels, R.W.; Alden, D.G.; Kanarick, A.F.; Gray, T.H.; Feuge, R.L. Automated Operator Instruction in Team Tactics. Naval Training Device Center, Orlando, Florida, NAVTRAEQUIPCEN 70-C-0310-1, January, 1972.

5 ABSTRACT:
PURPOSE: The purpose of the report was to determine the applicability of advanced technologies such as generalized or adaptive training to team training.
METHOD: Team task data were analyzed to determine whether sufficient commonality existed among tasks to warrant a generalized approach to team training. Three tactical team trainers--Devices 20A62, 21A38, and 2F69B--felt to be representative for surface, submarine, and aircraft operations, respectively, were selected for study. Behavioral scientists in groups of at least two at a time manually recorded verbal representations of the team tasks performed by all team members on each device. Later, each task statement was classified according to the three elements of stimulus, cognition, and response and were further described by a seven-digit code: (1) Stimulus Modality, (2) Stimulus Information Uncertainty, (3) Cognition/Perception, (4) Cognition/-Information Processing, (5) Cognition/Action Selection, (6) Response Modality, and (7) Response Complexity. A single exhaustive list of task descriptions for each position within the trainers was constructed. The data were analyzed to determine the commonality of tasks among the three training devices. Four additional analyses, concerned with specific parts of the seven-digit task codes, were conducted to define more clearly the commonality of tasks. These analyses identified Complexity Indexes, Stimulus Elements, Cognitive Elements, and Response Elements. Also a coding system was devised for identifying each task according to the person who performed it.
RESULTS: Little task commonality was found between Device 20A62 and either Device 21A38 or Device 2F69B. However, there was a 15.6% overlap in task descriptions between Devices 21A38 and 2F69B. A similar situation occurred in the Complexity Index analysis. There was greater commonality between Devices 21A38 and 2F69B than between either of these devices and the 20A62. Tasks in Devices 21A38 and 2F69B were characterized by fairly low stimulus and cognition complexity.

Key Number

The partial code analyses of Stimulus Elements, Cognitive Elements, and Response Elements revealed that the majority of the codes were common to all three devices. Similar results were found for commonality by operator category. Relatively few tasks were found to be common to all five operator categories with the seven-digit task code analysis. Instead, most task statements and seven-digit codes were unique to single operator categories. However, the partial code analyses showed that a vast majority of task codes were common to more than one of the five operator categories.

6 AUTHOR'S CONCLUSIONS:
"The Navy should concentrate on improving the effectiveness of existing devices rather than launching a development program for generalized training systems."

7 EVALUATION:
The implication of this study and recommendations for the manner in which training device development should proceed are discussed in detail and should be of use to anyone interested in team training. However, while the approach to task analysis focused on skill components, it was not established that variations in skill taxonomy require different training devices. Adaptable configurations of a single device might suffice in some instances, with special part-task trainers used for tasks for which the generalized device was not adequate.

10 AUTHOR'S RESEARCH SUGGESTIONS:
The following questions need to be answered: Can generalized training be effective for total teams? Is decision-making a generalizable skill? What is the best use of instructors in the learning process? If selected individu[illegible]mpting is used, what should be the schedule, specifici[illegible] nature of such prompts? What are the effects of promp[illegible] on nonprompted team members? What is the influence of various prompting schedules on transfer performance? What are the hardware and software requirements for simulating team members? What are adequate measures of team performance? Which multi-media instructional techniques should be selected for the training of which jobs. What should be their sequencing and relative durations?

14 DEPENDENT VARIABLES:
Team training effectiveness

15 INDEPENDENT VARIABLES:
Training technologies

Key Number	
22	SYSTEM/CLASS: Team training simulators
24	NUMBER OF PAGES: 0056
25	NUMBER OF REFERENCES: 0037
28	RESEARCH CLASS: Logical Study
29	RESEARCH METHOD: Logical analysis and description
36	REPORT TITLE: Automated Operator Instruction in Team Tactics
37	REPORT TITLE: Daniels, R.W.; Alden, D.G.; Kanarick, A.F.; Gra[illegible] H.; Fuege, R.L.
38	REPORT DATE: 72/01/00
40	ORIGINATING ACTIVITY: Systems and Research Division, Honeywell, Inc., St. Paul, Minnesota
44	CONTRACT/PROJECT/TASK: N61339-70-C-0310/NAVTRAEQUIPCEN Task No. 8505-1
48	REPORT NUMBER: NAVTRAEQUIPCEN 70-C-0310-1
49	OTHER REPORT NUMBER: 1244-FR[illegible]
52	PUBLISH[illegible] SPONSOR: Naval Training Device Center, Orlando, Florida
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited

Key Number	
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 038
13 January 1978

Key Number

1 ACCESSION NUMBER: AD-A007 721

4 CITATION:
Haygood, R.C.; Leshowitz, B.; Parkinson, S.R. Visual and Auditory Information Processing Aspects of the Acquisition of Flying Skill. Air Force Systems Command, Brooks Air Force base, Texas, AFHRL-TR-74-79, December, 1974.

5 ABSTRACT:
PURPOSE: The purpose of this study was to clarify the role of information processing variables in the acquisition of flying skill by: (1) identifying significant information-processing skills required in the operation of aircraft; (2) reviewing existing literature on laboratory studies of information processing; and (3) designing and executing the necessary experiments to advance existing knowledge in directions relevant to pilot training.
SUMMARY: The research was basically exploratory in nature with the broad spectrum of information processing tasks investigated ranging from simple identificaton of nonverbal stimuli to complex rule learning and concept formation. Three major areas were studied: (1) sensitivity and variability--to isolate information processing skills sensitive to individual differences and determine the extent of such capability; (2) control--to explore means for controlling or accounting for such individual variability; and (3) application--to ascertain the degree to which these tasks are applicable to pilot training and to provide a means for their implementation. The importance of the following auditory and visual information processing variables were demonstrated: stimulus duration; stimulus similarity interferences; response-induced interferences; attention; digit span; and scanning strategies. Audio-visual concept formation was demonstrated with simple problems, showing that auditory or visual information was equally effective when scanning time was unlimited, that visual-pictorial information was more effective than visual-verbal information when scan time was severely limited, and that there was no measureable effect of audio-visual redundancy on concept attainment performance over the range of test tasks studied.

6 AUTHOR'S CONCLUSIONS:
The authors concluded "that experimental procedures developed could be employed to probe further the non-optional information

Key Number

processing strategies of student pilots and to evolve more effective flying training methods."

7 EVALUATION:
This report was a well written and organized interpretation of a number of experimental studies of human auditory and visual information processing. The report adequately reflects the potential interfering effects of processed flying task information.

14 DEPENDENT VARIABLES:
Information processing

15 INDEPENDENT VARIABLES:
Sensory mode

24 NUMBER OF PAGES:
0059

25 NUMBER OF REFERENCES:
0095

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Logical analysis and description

36 REPORT TITLE:
Visual and Auditory Information Processing Aspects of the Acquisition of Flying Skill

37 REPORT AUTHOR:
Haygood, R.C.; Leshowitz, B.; Parkinson, S.R.

38 REPORT DATE:
74/12/00

40 ORIGINATING ACTIVITY:
Arizona State University, Tempe, Arizona

44 CONTRACT/PROJECT/TASK:
F41609-72-C-0037/61102F/11380102

48 REPORT NUMBER:
AFHRL-TR-74-79

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

Key Number

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 039
13 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Jeantheau, G.G. Handbook for Training Systems Evaluation. Naval Training Device Center, Orlando, Florida, NAVTRADEVCEN 66-C-0113-2, January, 1971.

5 ABSTRACT:
PURPOSE: The purpose of this report is to present the basic notions underlying training device effectiveness in the context of practical constraints on research in training device settings.
SUMMARY: Four levels of evaluation were discussed: (1) qualitative assessment, (2) noncomparative measurement, (3) comparative measurement, and (4) transfer of training. The first level, qualitative assessment, does not involve measurement of any kind, but is based on judgments made against a prior criteria of cost of the device, and the training situation that research and experience have shown contribute to effectiveness. Data are gathered from documentation review, interview with training and operational personnel, and observation of training. To be effective, the device and the training conducted with it should have these features: specified training objectives; sufficient structure and control of training regimens, including graded difficulty levels; and feedback and sequencing based on objective measurement. The next level, noncomparative measurement, is the crudest form of quantitative assessment. It involves a measurement of training performance from the beginning to the end of training. The gain scores represent the effectiveness of training with the device. The rationale is that if the measurement scheme has content validity as judged by subject matter experts, and if performance improves along pertinent dimensions, then the trainer is effective. Level three, comparative measurement, is where statistical evidence and experimental control come into play. Comparisons of group progress using different media or training regimens are the bases for evaluating separate media and regimens. To insure comparability between situations, control must be exercised over the training. Local constraints must be explored to determine allowable limits of deviation from the normal course of training. The final level, transfer of training, requires establishing that training in the simulator results in improved performance in an operational situation. Each succeeding level provides increasing rigor and entails increased problems of

Key Number

coordination and cooperation with the training activity, but provides the investigator with increasing levels of validity and reliability.

7 EVALUATION:
This report is well written and well organized. Illustrations and blank evaluation forms help clarify the discussion. Evaluation techniques are placed in perspective relative to each other and to situational constraints that affect their utility.

14 DEPENDENT VARIABLES:
Validity and reliability of training effectiveness evaluations

15 INDEPENDENT VARIABLES:
Procedures for determining training effectiveness

22 SYSTEM/CLASS:
Simulators

24 NUMBER OF PAGES:
0076

25 NUMBER OF REFERENCES:
0015

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Logical analysis and description

32 DESCRIPTIVE NOTES:
Final Report June 1966 - July 1969

36 REPORT TITLE:
Handbook for Training Systems Evaluation

37 REPORT AUTHOR:
Jeantheau, G.G.

38 REPORT DATE:
71/01/00

40 ORIGINATING ACTIVITY:
Dunlap and Associates, Inc., Darien, Connecticut

44 CONTRACT/PROJECT/TASK:
N61139-66-C-0113/7789-2A

Key Number	
48	REPORT NUMBER: Technical Report NAVTRADEVCEN 66-C-0113-2
49	OTHER REPORT NUMBER: DAC 69-129
52	PUBLISHER/SPONSOR: Naval Training Device Center, Orlando, Florida
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: No foreign release
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 040
16 January 1978

Key Number

1 ACCESSION NUMBER: AD-A022 251

4 CITATION:
Beardsley, H.; Bunker, W.; Eibeck, A.; Juhlin, J.; Kelly, W.; Page, J.; Shaffer, L. Advanced Simulation in Undergraduate Pilot Training: Computer Image Generation. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-75-59 (5), November, 1975.

5 ABSTRACT:
PURPOSE: The purpose of this report was to document the technical development and capabilities of the Advanced Simulation for Undergraduate Pilot Training (ASUPT) visual simulation system and its related technology.
SUMMARY: The report provided a description of the computer image generation (CIG) visual system developed for the ASUPT program. It was the fifth of seven volumes describing the ASUPT system which included (a) an overview; (b) motion system development; (c) g seat development; (d) automatic instructional systems; (e) computer image generation; (f) visual display development; and (g) systems integration. A CIG system was developed to provide a visual simulation of the terrain and other aircraft for research operations in the T-37B. The ASUPT system is composed of three major components: (a) two basic simulators; (b) two in-line infinity displays; and (c) a shared CIG system. The two simulators are interfaced and driven by a computer with sufficient computation capacity for simultaneous operation of both simulators. The visual display consists of seven mosaicked optical channels that provide the pilot approximately ±120 degrees horizontal by +120, -40 degrees vertical field of view (FOV). The CIG video signal, generated by a special digital computer, is similar to that generated by a TV camera, but without the TV camera constraints. The CIG system uses a numerically stored model and simulator flight data to generate the video signals which drive two 7-channel CRT display systems. The video signals are generated for display to a simulator pilot in real time and provide visual cues for the pilot's control of the simulator. The real-time operation generates a completely new visual scene each 1/30 of a second. The physical environment simulated by the CIG system is numerically described in three-dimensional vector space. The space consists of a flat surface, which represents the surface of the earth, and three-dimensional objects in the physical environment. Modeling for CIG is conveyed by means of

Key Number

straight lines, convex polygons, and gray shades. The straight lines, or edges, are used as boundaries of convex polygons, or faces, that are assigned a gray shade. The edges and faces are defined in three dimensions, with all two-dimensional and three-dimensional features of the environment depicted by them. The modeling concerns itself with the identification and definition of the key visual cues in a given scene. Once the scene has been described, the edges are converted to numerical data in X, Y, and Z coordinates which are formatted and stored in the CIG system for use in creating a perspective display image in real time.

6 AUTHOR'S CONCLUSIONS:
"All of the performance requirements . . . were met as measured at the CIG . . . computer output. All of the significant performance parameters were met for system operation (except for display contrast for 5 of the 14 display channels) . . . Some ringing was noted in the video on several channels; some noise was noted on the raster lines of several channels; a slight drift in raster interlace was noted; horizontal resolution was noted to be poor in one channel; slight distortions in the raster were noted on a few channels and some local brightness variations were noted . . . The general image quality appears to be good when an environment data base scene is viewed."

7 EVALUATION:
This report is valuable both for describing capabilities of the ASUPT, and for understanding current state-of-the-art CIG. It is lengthy and generally difficult to follow, however. It borders on the redundant and the reader is frequently submerged in technical data. The many pictures and figures add to the report and aid greatly in clarification.

14 DEPENDENT VARIABLES:
Visual display

22 SYSTEM/CLASS:
Computer image generation

24 NUMBER OF PAGES:
0271

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Structural analysis

040-2

Key Number

36 REPORT TITLE:
Advanced Simulation in Undergraduate Pilot Training: Computer Image Generation

37 REPORT AUTHOR:
Beardsley, H.; Bunker, W.; Eibeck, A.; Juhlin, J.; Kelly, W.; Page, J.; Shaffer, L.

38 REPORT DATE:
75/11/00

40 ORIGINATING ACTIVITY:
Space Division, General Electric Company, Daytona Beach, Florida

44 CONTRACT/PROJECT/TASK:
F33615-72-C-1717/11920292

48 REPORT NUMBER:
AFHRL-TR-75-59(5)

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 041
16 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Micheli, G.S. Analysis of the Transfer of Training, Substitution and Fidelity of Simulation of Training Equipment. Naval Training Equipment Center, Orlando, Florida, TAEG Report 2, 1972.

5 ABSTRACT:
PURPOSE: The purpose of the report was to summarize, evaluate, and synthesize data on the value of training devices. SUMMARY: "Training effectiveness" was defined as a measure of transfer of training according to two methods: per cent transfer, the difference between control and experimental groups in performance or time required on the operational task divided by the control group's performance or time required, with this figure multiplied by 100; the transfer effectiveness ratio (TER), the time saved in the operational task, divided by the time required in the training device. The results of several studies, presented in terms of per cent transfer and TERs, demonstrated that flight simulator training transferred to aircraft and could be substituted for some flight time. The prohibitive cost of flying, crowded air space, and threats to flying safety were listed as reasons to substitute flight with training devices when possible. Complete substitution for training in the air by training in devices was seen as a realistic goal, though with constraints due to less than 100 per cent simulator fidelity, lowered stress and motivation, and missing the joy in flying. In a study involving the Tracked Vehicle Driving Trainer (Device 3A105), driver training using the device was shown to be as effective as training in the actual tank. An evaluation of the Carrier Air Traffic Control Center portion of a large Tactical Advanced Combat Direction and Electronic Warfare System showed that increasing the time spent in the trainer resulted in increased performance at sea and that team, subteam, and individual capabilities to deal with recovery contingencies and emergencies improved. Using Device 2F69B, P-3A Aircraft Weapon System Trainer, performance of ASW crews increased throughout five sessions despite the fact that instructor aid was systematically decreased, while at the same time task difficulty increased. A study of Device 14A2, Surface ASW Attack Trainer, reached two conclusions: The trainees did learn in the trainer, but they rapidly forgot what they learned when they went to sea. A method developed by Caro to predict

Key Number

transfer, Equipment-Device Task Commonality Analysis, was tested and found useful. A discussion of the issue of high fidelity in simulation arrived at the conclusion that training effectiveness was more a function of the manner in which the trainer was used than of its fidelity.

6 AUTHOR'S CONCLUSIONS:
"The military should boldly adopt the policy" of substituting practice in training devices for flight time.

7 EVALUATION:
This report is useful as a brief summary of data on the value of training devices. However, the effect of device fidelity on transfer of training was not really addressed although the title of the report suggests otherwise.

14 DEPENDENT VARIABLES:
Transfer of training

15 INDEPENDENT VARIABLES:
Various training devices

22 SYSTEM/CLASS:
Training devices

24 NUMBER OF PAGES:
0039

25 NUMBER OF REFERENCES:
0046

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Survey/evaluative

32 DESCRIPTIVE NOTES:
Final Report: February 1972 - June 1972

36 REPORT TITLE:
Analysis of the Transfer of Training, Substitution and Fidelity of Simulation of Training Equipment

37 REPORT AUTHOR:
Micheli, G.S.

38 REPORT DATE:
72/00/00

Key Number

40 ORIGINATING ACTIVITY:
Training Analysis and Evaluation Group, Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
Work Assignment No. 1042

48 REPORT NUMBER:
NAVTRAEQUIPCEN TAEG Report No. 2

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 042
16 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Isley, R.N.; Prophet, W.W.; Corley, W.E.; Caro, P.W. Cost and Training Effectiveness Analysis (CTEA) of Device 2B12B. Human Resources Research Organization, Alexandria, Virginia, HumRRO FR-ED-77-9, May, 1977.

5 ABSTRACT:
PURPOSE: Two previous reports sought to determine the value of Device 2B12B in Army National Guard (ARNG) UH-1 helicopter flight training and the cost-benefit aspects of its use. This third report proceeded to integrate that information and to compare the 2B12B with other training alternatives.
SUMMARY: Four training sytem alternatives were compared: (a) conduct all training in the UH-1 aircraft; (b) conduct training in the UH-1FS and the UH-1 aircraft; (c) conduct training in the existing fixed wing Device 2B12A and the UH-1 aircraft; and (d) conduct training in Device 2B12B and the UH-1 aircraft. The 2B12A and 2B12B devices were low cost, low fidelity trainers with fixed wing and rotary wing configurations, respectively. They were not designed for specific aircraft, and possessed no cockpit motion systems or capability of simulating in-flight emergencies. In contrast, the UH-1FS was an expensive high-fidelity simulation of the instrument flight tasks and environment of the UH-1 helicopter. Training in the UH-1FS had been shown to be equal on at least an hour-for-hour basis to training time in the UH-1 helicopter. "Evaluation of Device 2B12B was based on examination of the Aviation Board user test, interviews with ARNG user personnel, observations of 2B12B training, examination of Device 2B12B and proposed future modifications to it, and on a Task Commonality Analysis (TCA)" (a comparison of device and aircraft tasks to provide a basis for predictions of transfer of training). Devices 2B12A and 2B12B behaved similarly in producing little or no transfer in terms of reducing flight hours required to meet the Standard Instrument Rating performance criteria. The user test and the TCA revealed discrepancies between the instrumentation and controls of the 2B12B and the UH-1 which were predicted to cause negative transfer. The releasing of flight controls necessary to operation of the 2B12B because of its single-place configuration, and the lack of copilot position and controls in the 2B12B, were judged to be detrimental to training effectiveness. More than one-half

Key Number

of the procedural items required in the UH-1 were not simulated at all in the 2B12B. While neither the 2B12A nor the UH-1FS were subjected to a detailed TCA, they were reviewed in this perspective by the project staff which was experienced with both devices. While the fixed wing configuration of Device 2B12A gave it a lower face validity than the 2B12B for rotary wing instrument training, the difference in overall effectiveness was seen as negligible because of the low fidelity of the 2B12B overall rotary wing simulation. In contrast, the UH-1FS demonstrated maximum task commonality with the UH-1 and in fact was shown to be a more efficient training environment than the aircraft itself. Training costs for the various alternatives were estimated by combining training hours required under each alternative with the cost per training hour. The training costs of Devices 2B12A and 2B12B were essentially the same and neither offered any likelihood of reducing total training costs. Use of the UH-1FS was seen to be cost effective and would allow training to the Standard Instrument Rating skill level at savings of approximately $4,000 to $9,500 per trainee when compared to either the 2B12A or 2B12B. Comparisons were made as to the "relative worth," defined as relative effectiveness divided by relative cost of the various alternatives, comparing two of them at a time. The UH-1FS worth was shown to be about three to four times that of either Device 2B12A or 2B12B.

6 AUTHOR'S CONCLUSIONS:
The UH-1FS is clearly the most training effective and least costly training device and it should be available to as many aviators as possible. Modifications of the 2B12B, the most expensive device to use, are not likely to improve significantly its training capabilities, but if the device continues to be used, a copilot station should be added, based on a detailed training requirements specification.

7 EVALUATION:
The cost and training effectiveness analyses were thorough and good use was made of equipment-device task commonality analysis. This study is of value as a description of an evaluative technique as well as for its findings regarding the devices.

14 DEPENDENT VARIABLES:
Cost effectiveness; training effectiveness

15 INDEPENDENT VARIABLES:
Nature of training device

18 SPECIAL ANALYTIC TECHNIQUES:
Equipment-device task commonality analysis

Key Number	
22	SYSTEM/CLASS: Helicopter flight simulators/Device 2B12A, 2B12B, and UH-1FS
24	NUMBER OF PAGES: 0049
25	NUMBER OF REFERENCES: 0019
28	RESEARCH CLASS: Logical Study
29	RESEARCH METHOD: Logical analysis and description
33	SUPPLEMENTARY NOTES: Research performed by Seville Research Corporation under sub-contract to the Human Resources Research Organization, Alexandria, Virginia
36	REPORT TITLE: Cost and Training Effectiveness Analysis (CTEA) of Device 2B12B
37	REPORT AUTHOR: Isley, R.N.; Prophet, W.W.; Corley, W.E.; Caro, P.W.
38	REPORT DATE: 77/05/00
40	ORIGINATING ACTIVITY: Seville Research Corporation, Pensacola, Florida
44	CONTRACT/PROJECT/TASK: HumRRO No. SE-77-12-21 DAAG 39-77-C-0030
49	OTHER REPORT NUMBER: HumRRO FR-ED-77-9
52	PUBLISHER/SPONSOR: Human Resources Research Organization, Alexandria, Virginia
56	TYPE OF PUBLICATION: Final report
64	LOCATION SYMBOL:

Key Number	
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 043
26 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Rolfe, J.M.; Hammerton-Fraser, A.M.; Poulter, R.F.; Smith, E.M.B. Pilot Response in Flight and Simulated Flight. ERGONOMICS, 13(6), 761-768, 1970.

5 ABSTRACT:
PURPOSE: The purpose of the study was to assess two types of response, control activity and physiological activity, as indications of the effect on simulator fidelity of adding pitch motion cues.
METHOD: Nine experienced service pilots undertook the same instrument flight plan under three conditions: (a) flight in the Hunter T7 aircraft; (b) simulator flight in a general purpose research simulator with pitch motion present; and (c) simulated flight in the simulator without motion. The order in which the conditions were undertaken was randomized within the group of Ss and almost all the flights were taken at the same time of day. Control activity was measured by a record of fore and aft movements of the control column. Physiological measures included heart rate, skin resistance, and respiratory rate. An individual baseline for each S's physiological responses was established by recording his physiological activities while resting in the simulator cockpit before each flight.
RESULTS: The extent of control column movements exhibited during the initiation of both descending and ascending turns was significantly different (p .LT. .001) for the three conditions, with motion bringing control activity in the simulator closer to that obtained in the air. Forward and backward movements of the stick were then analyzed separately during the termination of descending turns. Significant differences between groups were not found for forward stick activity, but were found for backward stick activity (p .LT. .05). Mean amplitudes of backward stick movement in the fixed simulator were greater than those in the moving simulator, the opposite of what was observed during the initiation of the turn. It was hypothesized that inappropriate stick activity during the beginning of this maneuver resulted in the need for excessive control movements at its termination. In the termination of ascending turns, no significant differences between conditions were noted for backward stick activity, although a .02 significance level difference was found in forward stick

Key Number

activity with the least activity in the flight condition and greatest activity in the fixed simulator condition. Individual baseline heart rate, skin resistance, and respiratory rate resting scores were examined for consistency, and heart and respiratory rates were found to be consistent but not skin resistance. Neither heart nor respiratory rate exhibited any significant differences between conditions. However, within both the flight and moving simulator conditions, heart rate was significantly higher during the performance of maneuvers as compared to either level flight or resting.

6 AUTHOR'S CONCLUSIONS:
Despite its limitations, the addition of pitch motion caused changes in Ss' responses which suggested that the fidelity of simulation was improved. "Control activity and physiological response proved to be practical and informative methods of comparing flight and simulated flight conditions." "The comparison of intra-subject difference, expressed in terms of deviation from a basal level, was an effective method of handling physiological response." Heart rate was the most useful physiological response for indicating similarities and differences between task conditions.

7 EVALUATION:
The dependence of control column activity on motion fidelity was clearly demonstrated. However, physiological measures did not differentiate the motion conditions, and thus the authors' conclusion that both "Control activity and physiological response proved to be practical and informative methods of comparing flight and simulated flight conditions" was overdrawn.

14 DEPENDENT VARIABLES:
Control column activity; heart rate; respiratory rate; skin resistance

15 INDEPENDENT VARIABLES:
Simulator motion fidelity

16 MEASUREMENT/STATISTICAL METHODS:
Friedman two-way ANOVA

22 SYSTEM/CLASS:
Flight simulator

23 SUBJECT POOL:
Experienced service pilots

24 NUMBER OF PAGES:
0008

043-2

Key Number

25 NUMBER OF REFERENCES:
0012

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

36 REPORT TITLE:
Pilot Response in Flight and Simulated Flight

37 REPORT AUTHOR:
Rolfe, J.M.; Hammerton-Fraser, A.M.; Poulter, R.F.; Smith, E.M.B.

38 REPORT DATE:
70/00/00

40 ORIGINATING ACTIVITY:
Royal Air Force Institute of Aviation Medicine, Farnborough, Hants, England

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 044
26 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Brictson, C.A.; Burger, W.J. Transfer of Training Effectiveness: A7E Night Carrier Landing Trainer (NCLT) Device 2F103. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN 74-C-0079-1, August, 1976.

5 ABSTRACT:
PURPOSE: The purpose of the study was to assess the transfer of training effectiveness of the Night Carrier Landing Trainer (NCLT) Device 2F103.
METHOD: Fifty-three Category 1 Replacement Pilots (RPs) who were assigned to VA-174 and had no previous A7E experience served as Ss. Twenty-six were chosen for NCLT training; the remaining twenty-seven for no-NCLT training. Roughly half of each group consisted of newly designated aviators from the training command (Nuggets) while the other half consisted of RPs with previous jet experience. The NCLT, a part-task trainer designed to simulate A7E night carrier landings, included "a simulated A7E cockpit, a visual display system, a three degree-of-freedom motion system, instructor console, digital computer and related hydraulic and electrical supplies." In addition to a visual display and aircraft motion and noise, the trainer was able to simulate carrier arrestment, bolter, touch-and-goes, and wave-offs. NCLT training time was manipulated through the number of final approach (ball control) trials provided; the experimental group received an average of 80 ball control passes during four hours in the NCLT. The following criteria were used to measure transfer of training effectiveness: (a) approach performance score (APS)--radar measures of aircraft variables during final approach; (b) landing performance score (LPS)--an objective measure derived from wire arrestment or wave-off data and weighted according to quality by LSO consensus; (c) boarding rate--per cent of final approaches resulting in touching down beyond arrestment wires; (e) wire arrestment--frequency distribution of wire numbers caught during carrier qualification (CQ); (f) subjective LSO scores; (g) pilot questionnaires; and (h) success/attrition rate--the number of RPs who pass/fail CQ.
RESULTS: NCLT trainees had significantly higher night LPS scores (p .LT. .02), higher night boarding rates (p .LT. .05), and a lower attrition rate (4%) than no-LCLT trainees

Key Number

(30%; p .LT. .006). LSO evaluations of night final approach and carrier landings were significantly higher for the NCLT group (p .LT. .003). For one class of RPs, radar measures of final approaches were recorded. Although there were no statistically significant differences between means of altitude error from glideslope, NCLT performance showed less variability about the mean (more precise performance) than was true of no-NCLT performance. No significant differences between groups were found in mean performance or variability of night lateral error at any of the four ranges from touchdown. Night sink rate (vertical velocity) measures showed no significant differences between means of the two groups, but the NCLT group scores exhibited less variability and were closer to desirable sink rates. Radar measure of night wire arrestment showed that no-NCLT trainees tended to fly a shallower glideslope and to catch early wires with low sink rates while NCLT trainees exhibited more precise glideslope control and tendency to catch proportionately more late wires with sink rates closer to desired levels. No statistical significance was found between the two groups for overall night Field Carrier Landing Practice (FCLP) performance. The no-NCLT trainees had slightly more unsuccessful approaches (bolters and wave-offs) than did the NCLT group. All night performance differences between the two groups became larger when Nuggets were separately analyzed. NCLT training results in greater positive transfer for Nuggets than for experienced pilots. Especially notable was the 44% attrition rate of no-NCLT Nuggets during CQ training compared to only 8% for NCLT Nuggets. These recycled attrites required an extra 12 weeks training and 19% more flight time to qualify as fleet pilots. Results of a questionnaire completed by NCLT trainees comparing the trainer's fidelity to actual night CQ experiences yielded favorable opinions of the NCLT as a procedures trainer but indicated that aircraft response dynamics could be improved.

6 AUTHOR'S CONCLUSIONS:

Positive NCLT transfer of training was demonstrated, especially for Nugget pilots. Another "measure of the NCLT transfer of training effectiveness can be found in the general reduction of RAG (Replacement Air Group) training time and flight time required to qualify Nugget pilots for fleet assignment." NCLT trained pilots exhibited more precision in vertical flight control than no-NCLT pilots. "The NCLT is an effective procedures trainer, helps the pilot build a perceptual scan, and, for the most part, adequately replicates the night carrier landing visual environment." "Night FCLP performances as graded by LCOs tend to be higher for NCLT trained Pilots and appear to stabilize after 50 night FCLP approaches."

Key Number

7 EVALUATION:
This well-described and well-designed study is very useful in evaluating NCLT training effectiveness for night carrier landings. Data were also presented on day carrier landings as a matter of interest and they showed that NCLT training did not produce significant transfer effects. Numerous tables and graphs presented the data vividly.

10 AUTHOR'S RESEARCH SUGGESTIONS:
"The possibility of substituting NCLT training for certain portions of FCLP training across different types of CAT 1 pilots should be investigated in a field study similar to the one documented here." "The transfer of training effectiveness of NCLT for refresher CQ training using fleet qualified pilots should be determined."

14 DEPENDENT VARIABLES:
Performance on night carrier landings; success/attrition rate

15 INDEPENDENT VARIABLES:
Night carrier landing trainer (NCLT) training vs. no-NCLT training

16 MEASUREMENT/STATISTICAL METHODS:
t test

22 SYSTEM/CLASS:
Night carrier landing training Device 2F103

23 SUBJECT POOL:
Category 1 A7E replacement pilots

24 NUMBER OF PAGES:
0093

25 NUMBER OF REFERENCES:
0017

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

36 REPORT TITLE:
Transfer of Training Effectiveness: A7E Night Carrier Landing Trainer (NCLT) Device 2F103

Key Number

37 REPORT AUTHOR:
Brictson, C.A.; Burger, W.J.

38 REPORT DATE:
76/08/00

40 ORIGINATING ACTIVITY:
Dunlap and Associates, Inc., Western Division, La Jolla, California

44 CONTRACT/PROJECT/TASK:
N61339-74-C-0079/NAVTRAEQUIPCEN Task No. 4751-1-P-1B

48 REPORT NUMBER:
NAVTRAEQUIPCEN 74-C-0079-1

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 045
23 November 1979

Key Number

1 ACCESSION NUMBER: AD-A008 197

4 CITATION:
Woodruff, R.R.; Smith, J.F. T-4G Simulator and T-4 Ground Training Devices in USAF Undergraduate Pilot Training. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-74-78, November, 1978.

5 ABSTRACT:
PURPOSE: The purpose "was to investigate the utility of . . . an AF37A-T4G flight simulator . . . (in) Air Force Undergraduate Pilot Training (UPT)."
METHOD: Ss were student pilots with "little or no flying experience." They were trained in 3 phases following the standard UPT syllabus except that proficiency advancement was used in the T-37; T-4/T4G instruction was blocked; instructor pilots (IPs) were used for all device training; the S/IP ratio was 1 to 1; and a special syllabus for the T-4G "incorporated modern concepts of the systems approach to training and programmed learning." The instructional sequence was (a) basic contact in the T-4G; (b) basic contact in the T-37; (c) instruments in the device; and (d) instruments in the T-37.
RESULTS: Average basic contact hours saved in the T-37, compared with data on other UPT students in the regular program, amounted to approximately 20 per cent for Phases 1 and 2, but no savings for Phase 3. Instrument training hours in the T-37 were reduced 45 per cent.

6 AUTHOR'S CONCLUSIONS:
The revised syllabus and training methods used would significantly increase instrument training efficiency, and similar (ISD) analyses should be completed for other programs.

7 EVALUATION:
The authors' conclusions seem justified. The systematic analyses of training needs apparently paid off. However, the use of proficiency advancement in the T-37 probably accounted for some of the reduction in training time.

14 DEPENDENT VARIABLES:
Flight hours saved

15 INDEPENDENT VARIABLES:
Specially devised syllabus versus standard syllabus

Key Number

22 SYSTEM/CLASS:
Flight simulators/T-4; T-4G

23 SUBJECT POOL:
Undergraduate pilot students with little or no flying experience

24 NUMBER OF PAGES:
0021

25 NUMBER OF REFERENCES:
0007

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Informal experiment

32 DESCRIPTIVE NOTES:
Final; February 1972 - June 1973

33 SUPPLEMENTARY NOTES:
Paper based on this research was presented at the Fourth Annual Symposium on Psychology in the Air Force, April 1974. AFHRL-TR-74-44 reports development of the syllabus in detail. AFHRL-TR-74-61 reports results achieved in first three phases of this study.

36 REPORT TITLE:
T-4G Simulator and T-4 Ground Training Devices in USAF Undergraduate Pilot Training

37 REPORT AUTHOR:
Woodruff, R.R; Smith, J.F.

38 REPORT DATE:
74/11/00

40 ORIGINATING ACTIVITY:
Flying Training Division, Williams Air Force Base, Arizona

44 CONTRACT/PROJECT/TASK:
62703F/11230303

48 REPORT NUMBER:
AFHRL-TR-74-78

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

Key Number	
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 046
30 January 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Fergenson, P.E.; Suzansky, J.W. An Investigation of Dynamic and Static Visual Acuity. PERCEPTION, 2, 343-356, 1973.

5 ABSTRACT:

PURPOSE: The purpose was to study the effects of dynamic visual acuity (DVA) of target angular velocity (AV) and target exposure time (ET). The correlation between DVA and static visual acuity (SVA) was also determined.
METHOD: Twenty-four male engineers with normal vision viewed the targets binocularly which were standard Landolt "C" rings reflected on a varying width rear projection screen. Widths of projected images controlled exposure time, and angular velocities were varied by adjusting the distance of the S from the screen. Ring gap positions were varied randomly. For each S, each of 4 exposure times of 0.4, 0.6, 0.8, 1.0s was paired with each of 4 angular velocities of 25, 30, 40, and 45 degrees per second (D/S). ET-AV condition sequences were counterbalanced across Ss, who were randomly assigned to a sequence and to a DVA-SVA order. Approximately 1 hour was required for each S during which he was dark adapted, familiarized with the task, and tested. Thresholds in minutes of visual angle (MA) for both ascending and descending target sizes were determined and averaged for each S.
RESULTS: Mean MAs were determined for each ET-AV condition. ANOVA yielded highly significant effects for AV, ET, and their interaction (see Comment), with MAs becoming larger for decreasing ET and increasing AV. Mean SVA (0.732MA) was significantly smaller (p .LT. .0005) than the smallest DVA mean (3.467MA). An immediate retest of condition AV = 30 D/S, ET = 0.6s permitted the determination of a reliability coefficient (r = .98) for that condition. Generally, DVA and SVA results were not correlated.

6 AUTHOR'S CONCLUSIONS:

DVA is determined by both AV and ET; DVA deteriorates with increased AV and decreased ET; SVA and DVA are not correlated, possibly because the latter depends on ocular-motor coordination (e.g., head movements) as well as visual acuity.

7 EVALUATION:

This experiment was carefully designed and adequate controls were maintained. Random assignments of Ss to condition

Key Number

sequences, and statistical checks on fatigue effects, assure that the data were not biased procedurally. Unfortunately, an apparent analytic mistake detracts from the overall quality of the report; however, assuming a positive correlation between AV-ET condition performances, the effect of the mistake was ANOVA significance levels probably lower then they would have been with an appropriate analysis. Specifically, a 4 x 4 factorial ANOVA was used with AV and ET as main effects and with S variance comprising a within error term. However, all Ss provided data for all 16 conditions, resulting in cross-condition correlations, so a between-S error term was likely too large. A 3-way ANOVA is indicated with Ss as the third dimension and SxAV and SxET becoming error terms for AV and ET, respectively, and SxAVxET for AVxET. This study was basic in orientation, so implications for aircraft and simulator design must be conceptual in nature. One such implication concerns the dependence of DVA on ET and AV as they in turn depend upon size of visual display and distance of display from an observer. Locations of display mounts relative to an observer is thus a matter of concern both for fidelity considerations and for optimum perceptual processing.

8 COMMENTS:
A significant AV by ET interaction was reported but not explained. From condition means provided it is readily apparent that any interaction must be due to increasingly larger AV effects as ET decreases, i.e., even though AV effects are linear for a given ET, the slope of an AV line is steeper for shorter ETs.

10 AUTHOR'S RESEARCH SUGGESTIONS:
Future research should include: (a) detailed experimentation with larger ranges of target speeds and exposure times; (b) studies of effects of illumination levels and contrast ratios; (c) the effects of target shape on DVA; (d) the relationship between DVA and performance in various tasks; (e) a study of the oculomotor system techniques used with various DVA conditions; and (f) a study of the conditions for and benefits of DVA training.

14 DEPENDENT VARIABLES:
Dynamic visual acuity; static visual acuity

15 INDEPENDENT VARIABLES:
Target angle velocity; target exposure time

16 MEASUREMENT/STATISTICAL METHODS:
Analysis of variance; t test; Pearson r

Key Number

23 SUBJECT POOL:
Male engineers

24 NUMBER OF PAGES:
0014

25 NUMBER OF REFERENCES:
0022

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
An Investigation of Dynamic and Static Visual Acuity

37 REPORT AUTHOR:
Fergenson, P.E.; Suzansky, J.W.

38 REPORT DATE:
73/00/00

40 ORIGINATING ACTIVITY:
Stevens Institute of Technology, Hoboken, New Jersey

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 047
23 November 1979

Key Number

1 ACCESSION NUMBER: AD-A009 638

4 CITATION:
Reid, G.B.; Cyrus, M.L. Transfer of Training with Formation Flight Trainer. Air Force Human Resources Laboratory, Brooks Air Force Base, Texas, AFHRL-TR-74-102, December, 1974.

5 ABSTRACT:
PURPOSE: The purpose was to determine the transferability of simulator practice in formation flying to aircraft performance.
METHOD, STUDY 1: Three groups of 24 Ss each were matched on the basis of average checkride scores at the end of T-37 training. On the average, Ss had completed 82.5 hours in the T-37 and 30 hours in the T-38. Group A was trained in an FFT simulator and then transitioned to the T-38. Group B had only an orientation flight in the T-38 during which all maneuvers were demonstrated and explained. Group C received all instruction in the T-38. The first T-38 sorties for A and C were demonstrations similar to the single ride for B. A total of 5 sorties were flown by A in the FFT, and by C in the T-38. Eight instructor pilots (IPs) were used, and rotated so that each S had a different IP from day to day. Check section pilots assessed T-38 formation flight performance while an IP flew the lead aircraft. The assessment occurred (apparently) on the first T-38 sortie for A and B, and the fifth for C. Standard undergraduate pilot training (UPT) grading was used except that each of the four grade categories was divided into three levels of proficiency.
RESULTS: Groups A and C were superior to B, but A and C did not differ significantly from each other. (A had the higher mean, however.)
METHOD, STUDY 2: Forty-eight Ss from a later class and with similar backgrounds were assigned to three groups using procedures similar to those in Study 1. The experimental procedures were the same except that instead of check section pilots, IPs were specially trained to collect assessment data.
RESULTS: Groups differed as before, and with the same pattern of significant and nonsignificant differences.

6 AUTHOR'S CONCLUSIONS:
"Results of these studies . . . provide conclusive evidence that the formation simulator is an effective training device."

Key Number

7 EVALUATION:
The statistical analyses were not appropriate. Groups had been matched, and the one-way ANOVA used requires independent groups. However, the result was to underestimate the significance of group differences. It is possible that Group A might have been significantly better than C.

10 AUTHOR'S RESEARCH SUGGESTIONS:
Instructional uses of the FFT and scheduling sequences should be defined.

14 DEPENDENT VARIABLES:
Checkride performance

15 INDEPENDENT VARIABLES:
Simulator versus T-38 training versus no training

16 MEASUREMENT/STATISTICAL METHODS:
Analysis of variance; Tukey's Honest Significance Test

22 SYSTEM/CLASS:
Formation flight trainer/FFT

23 SUBJECT POOL:
Undergraduate Air Force student pilots with averages of approximately 80 hours in the T-37 and 30 in the T-38

24 NUMBER OF PAGES:
0013

25 NUMBER OF REFERENCES:
0011

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

32 DESCRIPTIVE NOTES:
Final

36 REPORT TITLE:
Transfer of Training with Formation Flight Trainer

37 REPORT AUTHOR:
Reid, G.B.; Cyrus, M.L.

Key Number	
38	REPORT DATE: 74/12/00
40	ORIGINATING ACTIVITY: Flying Training Division, Brooks Air Force Base, Texas
44	CONTRACT/PROJECT/TASK: 62703F/11230205
48	REPORT NUMBER: AFHRL-TR-74-102
52	PUBLISHER/SPONSOR: Air Force Human Resources Laboratory, Brooks Air Force Base, Texas
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 048
7 February 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Brown, C.K.; Grant, A.J. Radar Landmass Simulation Computer Programming (Interim Report). Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN IH-212, January, 1973.

5 ABSTRACT:
PURPOSE: This report was an update describing operational software in use with NAVTRAEQUIPCEN's TRADEC System for producing a pseudo real-time radar display.
SUMMARY: The special hardware of concern together with associated software permit the simulation of simulation methods, comparing them against baseline results derived from processed raw digital radar data. The report focused on programs and subroutines that produce simulations of terrain and cultural factors (bodies of water plus man-made objects). All programs were written in XDS FORTRAN 4. The software operates on data bases to produce simulations of actual radar return of air-to-ground mapping. The steps involved in producing such a simulation are: (a) create cultural and terrain data bases; (b) define a flight path; (c) extract from the data bases the cultural and terrain data along the flight path; (d) define sector and sweep parameters; (e) obtain cultural and terrain profiles for each sweep and scan; (f) combine these profiles adding radar effects (shadow, etc.) to produce an intensity array; and (g) transmit intensity arrays to display hardware in sequence at real-time rate. The first step in producing terrain simulation is to store raw terrain data in grid format on magnetic tapes. All such data are then reformatted through software to a common coordinate system. This preliminary terrain data base is transferred to working tapes by a COPY program, then through an OFILL program all data columns are made equal in length. Data are further divided into "regions" of workable size through a DEGDIV program. Finally, a TERRPREP (terrain preparation) program produces height profiles. The steps involved in TERRPREP are: Main program reads flight path parameters; then calls for sub tine FLTPATH which computes X, Y coordinates, region nu ers, and heading for each radar scan line along th flight path; subroutine RADLOAD accesses tapes of data resulting from the REGDIV program which are appropriate for the flight path and loads them into a disc file. The main program then calls subroutine

Key Number

TERRSCAN which determines which regions lie along each sweep line of each scan, stores these, and when a complete height profile has accumulated, writes it onto an output tape. Because of the enormous volume of data to be accommodated, a data compression technique using nth-degree polynomials can be used which permits a desired degree of approximation through available coefficients for the polynomial. These generated data can be incorporated into the terrain simulating program in place of actual data. The cultural profile in turn must represent basic radar reflectance of cultural targets along a given sweep line. Again, appropriate raw data must be obtained which are digitized as points, lines, or polygons. Program PGM1 "reblocks" these data, corrects known errors, and closes open ended systems (e.g., rivers) so that they can be treated as polygons. A next program, PGM2, defines each feature by horizontal strips and "decides" which features reflect radar energy in a particular direction (special features) and which produce diffuse reflections. Then program PGM3 divides cultural data into regions comparable to those for terrain data, resulting in an output of horizontal strips within boundaries. PGM4 records PGM3 results along with priority assignments. PGM5, MERGE, establishes locality perspective or relations so that positions of objectives relative to each other are represented. PGM6 then "packs" these data and stores them on magnetic tape, which are then transferred to a random-access disc by PGM7. Finally, a cultural preparation program CULTPREP operates on PGM7 products to generate cultural profiles in a manner analogous to TERRPREP's treatment of terrain data. The integrating program ASANDDIS (Assemble and Display) combines TERRPREP and CULTPREP results and causes the composite to be displayed on associated hardware. ASANDDIS also simulates under selective control radar effects of shadowing, aspect angle (deflection of the incident radar beam), slant range (i.e., range of target from aircraft as opposed to ground range from point under aircraft), and aberrations resulting from finiteness of radar beam and pulse widths. Important aspects of actual radar images not simulated in the software at the time of this report (1973) were earth curvature, glitter, antenna lobe patterns, antenna tilt, atmospheric phenomena, and "others" not identified.

7 EVALUATION:

This report fulfilled its purpose. It identified, and gave brief but adequate descriptions of the several NAVTRAEQUIPCEN in-house programs and subroutines for radar landmass simulation which were extant in early 1973. The descriptions concerned only what could be accomplished by the programs, however; they did not identify programming strategies or details.

Key Number

10 AUTHOR'S RESEARCH SUGGESTIONS:
Although not suggested as research topics, some deficiencies in radar landmass simulation were identified. Specifically, simulation techniques are needed for earth curvature, glitter, antenna lobe pattern, antenna tilt effects, and atmospheric phenomena.

14 DEPENDENT VARIABLES:
Fidelity of radar landmass simulation

22 SYSTEM/CLASS:
Radar landmass simulation

24 NUMBER OF PAGES:
0013

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

36 REPORT TITLE:
Radar Landmass Simulation Computer Programming (Interim Report)

37 REPORT AUTHOR:
Brown, C.K.; Grant, A.J.

38 REPORT DATE:
73/01/00

40 ORIGINATING ACTIVITY:
Computer Laboratory, Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
NAVTRAEQUIPCEN Task No. 1743-05

48 REPORT NUMBER:
NAVTRAEQUIPCEN IH-212

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

Key Number

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 049
9 February 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Hazer, K., Jr.; Ringler, D.L. Applicability of Design-to-Cost To Simulator Acquisition. Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, SLSR 36-76A, June, 1976.

5 ABSTRACT:
PURPOSE: The purpose of the study was to determine the applicability of the Design-to-Cost (DTC) concept to simulator acquisition. Specifically, answers were sought to two questions: (a) Is there a set of common characteristics in weapon systems acquisition that permit a general application of the DTC concept? (b) If so, are they sufficiently descriptive of flight simulator acquisition programs to justify the use of DTC in contracts?
SUMMARY: DTC "is a management concept of establishing cost goals during design by practical trade-offs among requirements, capabilities, cost and schedule.", A literature review resulted in the identification of 26 program characteristics believed common to successful application of the DTC concept. Through interview, twenty-five of these characteristics were validated subjectively by 17 Air Force Systems Command personnel considered to be DTC experts. Based upon these 25 characteristics, a decision model was then designed in the form of a restructured managerial schedule which was used to interview four "knowledgable" personnel from the Simulator System Program Office (SPO). Of the 25 characteristics, 15 were considered by SPO personnel to be generally applicable to simulator acquisition, 4 not applicable, and 6 applicable only for certain program requirements (e.g., development of a new simulation system, or when extensive simulator production is required). Nevertheless, six major problem areas in applying DTC analyses to simulator acquisition were identified: (a) There seemed to be a lack of communication among top DoD management, Air Force Systems Command, and Air Force Logistics Command in setting DTC goals; (b) program managers were evaluated on how much they reduced acquisition costs rather than life cycle costs (LCC); (c) if a management information system for LCC existed, it was not used effectively; (d) cong[illegible]en are not particularly concerned with LCC, only with acqu[illegible]n costs; (e) prime contractors do not generally use DTC when dealing with subcontractors.

6 AUTHOR'S CONCLUSIONS:
The problems identified notwithstanding, DTC "seems to be achieving its intended purpose, which is to obtain quality weapon systems at an affordable cost through innovation and better cost management. DTC forces planning for the entire acquisition program. It creates a cost awareness throughout the DoD. It places more emphasis on making better cost estimates . . . (and) improves the overall budgeting process." Yet, DTC may not be generally applicable to the acquisition of small numbers of simulators because competition in private industry will "insure that the prices the Government pays will be fair and affordable."

7 EVALUATION:
This report is very wordy. Nevertheless, the entirely subjective data regarding useful DTC characteristics were treated well in discussions. The reader may have some difficulty coming to grips with DTC concepts because an analytic procedure was not provided. An example showing the integration of the DTC characteristics in an application would have been of great help. A second difficulty was the absence of data that would be needed to state categorically that all the six problems identified above are actually problems. To be of substantial use for simulator acquisition, advantages of DTC should be demonstrated in comparative cost analyses of actual acquisition programs.

10 AUTHOR'S RESEARCH SUGGESTIONS: (a) A case study on a program using the DTC concept should be undertaken. (b) The possibility of switching from DTC to another concept (e.g., Manufacture-to-Cost) somewhere during the acquisition cycle should be investigated. (c) A study is needed "to determine what incentives might be added to DTC type contracts which would motivate contractors and satisfy both their objectives and the objectives of the Government after the contract is signed and competition ceases." (d) The types of information to be gathered to make Design-to-Life Cycle Cost trade-off decisions in the future need to be identified. (e) The various uses of escalation clauses or other related alternatives should be investigated.

12 CROSS-REFERENCE:
Brown, C.K.; Grant, A.J. Digital Radar Landmass Simulation. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN IH-196, February, 1973.

14 DEPENDENT VARIABLES:
Simulator acquisition cost

Key Number

22 SYSTEM/CLASS:
Simulators

24 NUMBER OF PAGES:
0156

25 NUMBER OF REFERENCES:
0053

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Applicability of Design-to-Cost To Simulator Acquisition

37 REPORT AUTHOR:
Hazer, K., Jr.; Ringler, D.L.

38 REPORT DATE:
76/06/00

40 ORIGINATING ACTIVITY:
Graduate Education Division, School of Systems and Logistics, Wright-Patterson Air Force Base, Ohio

44 REPORT NUMBER:
SLSR 36-76A

52 PUBLISHER/SPONSOR:
Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio

56 TYPE OF PUBLICATION:
Master's thesis

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

049-3

ABSTRACT 050
13 February 1978

Key Number
1 ACCESSION NUMBER:

4 CITATION:
Brown, C.K.; Grant, A.J. Digital Radar Landmass Simulation. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN IH-196, February, 1973.

5 ABSTRACT:
PURPOSE: An earlier interim report (see Cross-References) described Naval Training Equipment Center operational in-house software to be used with the NAVTRAEQUIPCEN Sigma 7 computer for radar landmass simulation (RLMS). The earlier report identified generally what each program and subroutine accomplished, but provided no programming information. The present report describes technical characteristics of the interface hardware and presents program flowcharts, program listings and interface hardware schematics for this hardware.
SUMMARY: The interface hardware consists of three major subsystems, Deflection Generation (DG), Control and Clock (CG), and Direct Output Processor Registers and Associated Circuitry (DOPR). Deflections are generated by the interface system from two linear equations in which coordinates X, Y for a display at point N+1 are determined separately as X, Y at point N plus change delta X or delta Y. The slope of the sweep line is determine by delta X and delta Y. For each such set of increments the interface provides the Z axis of the display scope with a corresponding brightness level. The DG systems for X and Y provide each with a 24-bit register and 24-bit adder. Once initialized, a register can be incremented by amounts delta X or delta Y for each clock pulse. The contents of the X and Y registers are translated to respective X and Y deflection voltages. The CC system controls the timing of all events in the interface. It is comprised of a clock--a multivibrator which provides a signal to the rest of the interface; a 12-bit N-counter; and a main sequence control--a 4-bit counter that defines the specific sequence of events in the interface. The DOPR system accepts sweep line segments intensities and lengths which are then "read out" as required. The brief discussions of these subsystems are supplemented by detailed schematics in the appendices.

7 EVALUATION:
The 45 figures plus numerous tables of programming information provide a good description of the interface system and its

Key Number

capabilities with existing software. Also provided are program listings. However, for a fuller discussion of the software capabilities, the earlier report (see Cross-References) should be consulted.

12 CROSS-REFERENCES:
Brown, D.K.; Grant, A.J. Digital Radar Landmass Simulation Computer Programming (Interim Report). Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN IH-212, January, 1973.

14 DEPENDENT VARIABLES:
Fidelity of radar landmass simulation

22 SYSTEM/CLASS:
Radar landmass simulation

24 NUMBER OF PAGES:
0116

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

32 DESCRIPTIVE NOTES:
Interim Report (1969 - 1972)

36 REPORT TITLE:
Digital Radar Landmass Simulation

37 REPORT AUTHOR:
Brown, D.K.; Grant, A.J.

38 REPORT DATE:
73/02/00

40 ORIGINATING ACTIVITY:
Computer Laboratory, Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
NAVTRAEQUIPCEN Task No. 7884-10

Key Number	
48	REPORT NUMBER: NAVTRAEQUIPCEN IH-196
52	PUBLISHER/SPONSOR: Naval Training Equipment Center, Orlando, Florida
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 051
27 February 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Koonce, J.M. Effects of Ground-Based Aircraft Simulator Motion Upon Prediction of Pilot Proficiency. Air Force Systems Command, Brooks Air Force Base, Texas, ARL-74-5/AFOSR-74-3, April, 1974.

5 ABSTRACT:
PURPOSE: This study had five major and six subsidiary purposes. The major purposes were: to determine to what degree proficiency of aircraft pilot performance can be predicted from measures of ground-based simulator pilot performance; to determine the variability of the predictive validities of ground-based simulator pilot performance measures as a function of simulator motion conditions; to develop a reliable pilot performance rating scale that is useful and efficient for flight instructors and flight observers in an operational situation; to attempt the development of a pilot performance rating scale that will correlate highly with other indices of pilot performance; and to determine if a systematic, useful relationship exists between pilots' stated levels of confidence in their abilities and their measured performances. Subsidiary purposes were: to determine if predictive validity of pilot performance in a simulator varies as a function of contact (VFR, for visual flight rules) and instrument (IFR, for instrument flight rules) flight conditions; to determine the predictive validity of performance on specific simulated maneuvers; to determine if the predictive validity of performance on specific simulated maneuvers and on classes of flight (VFR and IFR) is dependent upon the simulator motion condition; to determine the effect upon reliability of pilot performance measures when the observer has additional duties such as Safety Pilot; to determine the relationships between observer ratings of overall mission performance and observer ratings of individual maneuver performances; and to determine the predictability of pilot proficiency from various indices of flight experience and currency.
METHOD: Ss, all volunteers, were 90 pilots with both multi-engine and instrument ratings. Using stratified sampling procedures, based on multi-engine and instrument time during past 6 months, 30 Ss were assigned randomly to each of three groups except that "toward the end" Ss were assigned so as to balance these two flight times. All Ss performed a simulated flight

Key Number

mission in a Singer-Link General Aviation Trainer (GAT-2) on each of two days. Group 1 experienced no cockpit motion, Group 2 had sustained linear, scaled-down analog motion, and Group 3 had washout motion. Each S then flew the same mission in a Piper Aztec, and on a later day one third of each group repeated the mission in an Aztec. The profile of the missions consisted of ten maneuvers: takeoff and climbout (T/O); cruise (CRU); holding (HOL); precision ILS approach (ILS); missed approach (MIS); 360 degree steep turn (360); chandelle (CHN); lazy eight (LZY): non-precision ADF approach (ADF); and landing (LNG). T/O, 360, CHN, LZY, and LNG were performed under VFR and the remainder under IFR. For each simulation and flight, each S was rated by a flight observer (FO) and a safety observer (SO), with no observer serving ratings and, except for one, all were certified flight instructors for multi-engine planes. The exception, an Air Force Pilot, had extensive multi-engine experience as a flight instructor and examiner. Preparatory to observing, each observer was given copies of the Pilot Performance Record (PPR) and other booklets, check lists, etc. to familiarize him with task requirements. Each observer also flew at least one GAT-2 mission himself prior to rating a S. Flight performance and procedural factors upon which Ss were rated were restricted to those that could be clearly defined, readily observed, and fairly objectively recorded. Redundancy of information from measures was generally avoided. In all, measures on 50 scale items and 79 categorical items were obtained for each S, as well as 11 ratings by each observer and 10 self-estimates of confidence by each S.

RESULTS: The results were presented in three phases; reliability of performance measures, the effects of the experimental conditions upon performance levels in the simulator and aircraft, and the prediction of proficiency in piloting the aircraft. Between-observer correlations of ratings on the same days were generally high, ranging from .77 to .97 for total performance, .89-.98 for IFR, and .48-.96 for VFR. (Product moment rs were used for scaled measures and phi coefficien... for categorical items. An r .GT. .30 has a p .LT. .05.) For individual maneuvers, correlations were also generally high except for CHN, LZY, and 360 on Day 3. The 180 correlations of day-to-day observations were generally lower for both same and different observers with most in the .50-.75 range. Only three failed to reach significance at the .05 level, however, and all three involved the SO on Day 3 for Group 1 VFR. Intra-observer rs tended to be higher than those between observers, and FO-FO rs tended to exceed those for FO-SO, but no significance tests for these differences were reported. The dependent variable used to determine effects of simulator motion on performance was derived from a combination of SO and FO ratings for each

Key Number

maneuver. ANOVA using Groups (G) and repeated measures on Days (D) was employed. All groups showed substantial improvement over days (p. .LT. .001). GxD interactions were significant for Total Mission (p = .001), combined IFR maneuver (p =.02), and combined VFR maneuvers (p .LT .01). The interpretation of these interactions was clarified by repeating the ANOVA as above except that only Days 1 and 2 (in simulator) were used. No GxD approached significance, implying that the previous interactions were due to differential changes in performance when tested in the aircraft where Group 1 errors especially were drastically reduced. Prediction of pilot proficiency was based first on composite FO-SO ratings combined across maneuvers and correlated across days. Group 2 rs were highest and Group 3 lowest. Total Mission correlations were highest for all groups, followed by IFR and VFR, respectively. Of primary importance is the prediction of Day 3 performance from measures made on Days 1 and 2, which were equally effective. For Total Mission, the median rs between simulator performance and that in the aircraft on Day 3 were .51, .71, and .50 for Groups 1, 2, and 3, respectively. For IFR, respective medians of .59, .78, and .54 were obtained, and for VFR, .37, .53, and .39. For all rs, ps were .LT. .05. Next, multiple correlations were determined using Day 2 measures on each of the ten maneuvers separately as predictors, and summed ratings (t) and observer's subjective evaluations (O) on Day 3 as separate criteria. Multiple rs with T were .72, .87, and .65 for Groups 1, 2, and 3, respectively, and .76, .91, and .73 with O. Multiple predictions were cross-validated by splitting observers into two groups, determining regression coefficients for one group, and correlating actual and predicted ratings for the other group. Considerable shrinkage occurred with rs ranging from .33 to .72. The small Ns employed in these and related correlational analyses prevented clear interpretations of specific rs. As for S self-confidence ratings, average rs were .26 with performance in GAT-2 and .22 in the aircraft (no significance data given). Correlations of age and performance were of questionable significance. Flight time during past six months generally correlated significantly with performance, although kind of flight time and total flight time did not.

6 AUTHOR'S CONCLUSIONS:

Proficiency of these Ss "can be predicted to a high degree from ground-based simulator performance measures" and especially for Group 3 (sustained motion) regardless of criterion task; predictive validity for IFR is greater than that for VFR; predictive validities for certain maneuvers such as holding, precision approach, and non-precision approach are greater than for steep turns, chandelle, and lazy eight; "high observer-observer reliabilities . . . on the same mission can be obtained by recording performance on scales that are well defined, easy

Key Number

to follow, descriptive of the maneuver and behavior being recorded, and are not too demanding" on the recorder. Also, recorded performance measures correlated "very highly" with observers' overall subjective ratings of performance, especially for IFR. Measures other than performance in GAT-2 did not correlate appreciably with mission performance. Additional conclusions were: "Simulator motion tends to increase the subject's acceptance of the device, lower performance error scores, and reduce workload on the subjects and . . . observers . . . But the differential effects of motion . . . (do) not transfer to the performance in the aircraft . . . . Increasing the fidelity of the simulator motion system may bring much of the variability in performance found in the aircraft into the simulated environment which was used to escape the variability of the operational environment."

7 EVALUATION:

This study was well designed and executed with care. Stratified samples assured comparability of groups, and observers were trained preparatory to their involvement in data collection. However, several difficulties are involved in interpretations of results. Most serious was the use of an inappropriate ANOVA design. Stratified sampling established correlations among groups, and repeated measures ANOVA assumes independent groups. Thus, Fs for groups were necessarily too low, and Fs for interactions probably too high. Another difficulty of undeterminable effect was the variation among Ss of from one day to three weeks between missions. Perhaps S schedule peculiarities that resulted in these variations were characteristic of all groups, but there is no way to be sure. More pertinent, however, are factors that affect the interpretation of results and qualify the author's conclusions. As noted above under RESULTS, the GxD interaction disappeared when data from only Days 1 and 2 (in the simulator) were analyzed. Examination of mean error scores for these and Day 3 shows that the significant 3-day GxD interaction was due entirely to Group 1 "catching up" when tested in the aircraft. Whereas this Group had greater error scores in the simulator, their performances were comparable, even slightly superior, to those of Groups 2 and 3 when tested the first time in an aircraft. Hence the conclusion, asserted without discussion, that "the differential effects of motion . . . (do) not transfer to the performance in the aircraft . . ." can be misleading. All Ss were experienced pilots and during the test in the aircraft flew equally well. It was in the simulator that Group 1 (no motion) was inferior! Therefore the transfer of training from simulator to aircraft was not the issue; rather, the question answered by this research was, "Given groups of experienced pilots, matched on total flying

Key Number

time and recent IFR experience, does simulator motion affect the transfer of those flying skills from aircraft to the simulator?" The answer was yes. Viewed in this manner, nothing in this study supports a generalization that simulator motion does not affect transfer. Conclusions regarding the other two major areas of concern, observer reliability and prediction of pilot performance, are more firmly based. Nevertheless, generalizations of the findings must be made carefully. Supporting data were almost entirely correlation coefficients, and the groups were small (N = 30 each) and extremely variable. This latter fact is of utmost importance because an r of .75, for example, had a 95% confidence interval of .53 to .88. Consider next the range in experience of these Ss: total flight time, 240 - 12,596 hours; multi-engine time, 10 - 10,000 hours; instrument time, 16 - 2,200 hours; simulator time, 0 - 600 hours. And for the 6 months just preceding the study: flight time, 0 - 999 hours; multi-engine time, 0 - 250 hours; instrument time, 0 - 78 hours. These variations surely resulted in considerable variations during the three days of testing as well, yielding similar simulator and aircraft performances for a given subject, but performance which would be well differentiated from those of Ss with considerably more or less experience. High rs between simulator and aircraft skill would thus be expected, but such would not be true for a homogeneous group of, say, undergraduate pilots. These differences in experiences would also affect observer reliabilities, because a nonzero reliability coefficient r is directly proportional to the variance, i.e., square of the standard deviation, of the true scores. The more different Ss are, the more consistently, i.e., reliably, they can be differentiated. So what conclusions are justified? The following are offered: (a) Motion in a simulator probably affects the transfer of aircraft skills of experienced pilots to simulator flight; (b) trained observers using objective scales and criteria can evaluate flight performance, but the degree of reliability for homogeneous groups of Ss is not known; (c) simulator performance is predictive, but to an unknown degree, of aircraft performance, at least for experienced pilots. A corollary to this last conclusion is that if training performance of novice pilots in a simulator is also predictive of aircraft performance, then simulator training has a positive transfer effect. Regarding the author's conclusion concerning the absence of motion effects, correlations between Day 2 simulator and Day 3 aircraft composite performance scores for sustained, washout, and no motion, respectively, were: Total Mission, .72, .49, .48; IFR, .81, .51, .58; VFR, .50, .38, .32. Note that r square, the proportion of predictable variance, is two or more times as great for sustained motion as for either of the other two conditions. Note also that such a finding supports the

051-5

Key Number

present writer's conclusion (a) just preceding, i.e., that motion in the simulator renders performance there and in the aircraft more similar, which must involve aircraft to simulator transfer.

14 DEPENDENT VARIABLES:
Adequacy of flight maneuvers as scaled and rated by flight and safety observers; observer rating reliability; prediction of flight performance

15 INDEPENDENT VARIABLES:
Pilot performance in simulators with continuous, washout, or no motion; visual vs instrument flight rules; between vs within observer ratings; pilot self-estimates of ability

16 MEASUREMENT/STATISTICAL METHODS:
Product moment r; phi coefficient; ANOVA; discriminant function

22 SYSTEM/CLASS:
Flight simulator/Singer-Link General Aviation Trainer (GAT-2)

23 SUBJECT POOL:
Pilots with multi-engine and instrument ratings

24 NUMBER OF PAGES:
0213

25 NUMBER OF REFERENCES:
0050

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Effects of Ground-Based Aircraft Simulator Motion Conditions Upon Prediction of Pilot Proficiency

37 REPORT AUTHOR:
Koonce, J.M.

38 REPORT DATE:
74/04/00

40 ORIGINATING ACTIVITY:
Aviation Research Laboratory, University of Illinois, Savoy, Illinois

Key Number

44 CONTRACT/PROJECT/TASK:
F44620-70-C-0105/9778/681313/61102F

48 REPORT NUMBER:
ARL-74-5/AFOSR-74-3

52 PUBLISHER/SPONSOR:
Air Force Office of Scientific Research, Air Force Systems Command

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 052
27 February 1978

Key Number
1 ACCESSION NUMBER:

4 CITATION:
Ung, M.T. Recommended Requirements for the Universal Aircraft Flight Simulator/Trainer. Air Force Flight Test Center, AFFTC-TR-74-23-, June, 1974.

5 ABSTRACT:
PURPOSE: This study had three stated objectives: (a) to provide a brief description of present facilities that might be recommended for inclusion in the final version of the Universal Aircraft Flight Simulator/Trainer (UAFS/T); (b) to summarize the types of mathematical models to be implemented on the future UAFS/T and identify their implications for computing systems; and (c) to generate a cost estimate of several computer system types which could be considered for the UAFS/T.
SUMMARY: The flight equations of concern in this study were cited but not actually provided in this report. They had been written in four coordinate systems: (a) body axes, (b) stability axes, (c) wind axes, and (d) earth axes. However, three refinements would be needed for the UAFS/T: For long distance missions (X - 24C, space shuttle) an oblate earth must be taken into account; during takeoff and landing the interaction between the aircraft and the ground must be added; and a target synthesizer would be required to conduct pursuit-evasion simulation. Until as recently as 1964, only analog computers were used for real-time simulation. However, even though the introduction of parallel logic removed some weaknesses of analog computation (e.g., lack of decision making capabilities, restrictions on branching), they still had only four-digit accuracy and lacked mass storage capability. On the other hand, digital computers were appropriate only when generally low performance requirements (cruising flights, takeoffs, landings, etc.) were needed. Digital simulation in real time for many maneuvers of high-performance military aircraft could not be attained at reasonable cost, even with third-generation computers. Digital flight simulation had been achieved through: the uncoupling of attitude control and trajectory equations which permitted their linearization and thus rectangular or trapezoidal integrations; and z-transforms or related techniques that made rapid numerical integrations possible. Hybrid systems offered advantages over either type of computer used separately. A small inexpensive digital computer could provide: (a) integration of translational

Key Number

equations of motion with high precision; (b) simulation of the on-board digital computer itself; (c) the generation of arbitrary functions of many variables; and (d) documentation and record keeping. The analog component could: (a) simulate dynamics of the control system; (b) solve the high-bandwidth rotational equations of motion; and provide man-machine interaction and tie-ins with flight hardware. Equipment existing in 1974 that could be incorporated into the UAFS/T included Data Systems CDC6500 and the existing Air Force Flight Test Center hybrid system. Three tables were provided showing several possible combinations of computer components and their required capacities. Fortran and assembler languages would be used for the bulk of the software package which would have four major subsets: Interface Run-time Library with emphases on speed of operations; Setup Checkout and Debug Package for altering flight conditions, etc.; Hardware Diagnostics Programs which could check the digital, interface, logic, and analog constituents; and Digital Simulation Language which would serve "as a dynamic check for one test case of the model to increase the programmer's confidence level . . ."

6 AUTHOR'S CONCLUSIONS:

For the time being, "a sensible and economical way to solve (six degrees-of-freedom) problems with all the on-board systems is with the hybrid computer . . . In due time the stick riddle of multiprocessing will be unraveled economically . . . (and) the digital computer will become a serious contender in the field of real-time flight simulation . . ."

7 EVALUATION:

This state-of-the-art report presented the author's recommendations and conclusions regarding desirable alternatives for computer simulation. Although data or logical justifications were provided. His points may generally be acceptable to one already knowledgeable about the strengths and weaknesses of digital and analog simulation computers. The organization of the report is sometimes confusing but it can be followed without much difficulty. Diagrams and flow charts provide sufficient technical information to guide in the development of such hybrid systems.

22 SYSTEM/CLASS:

Hybrid computer systems

24 NUMBER OF PAGES:

0028

25 NUMBER OF REFERENCES:

0011

Key Number

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Structural analysis

36 REPORT TITLE:
Recommended Requirements for the Universal Aircraft Flight Simulator/Trainer

37 REPORT AUTHOR:
Ung, M.T.

38 REPORT DATE:
74/06/00

40 ORIGINATING ACTIVITY:
The author himself: Man T. Ung, El Segundo, California

44 CONTRACT/PROJECT/TASK:
F04700-74-C-0328/JON 996000/PEC 65805F

48 REPORT NUMBER:
AFFTC-TR-74-23

52 PUBLISHER/SPONSOR:
Air Force Test Flight Center

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 053
27 February 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Derby, R.M. Simulation of a Digital Radar Landmass Simulator. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN 71-C-0207-2, January, 1973.

5 ABSTRACT:
PURPOSE: The purposes of this report were: to study the automatic conversion of existing representations of terrain elevation to a General Electric Digital Radar Landmass Simulator (DRLMS) format; to explore how varying terrain data compression parameters would affect the final display; to determine how the final terrain data should be specified; and to ascertain which of the several special displays are required for a particular mission.
SUMMARY: This report focused on three types of problems: terrain representation; cultural objects (man-made objects and bodies of water) representation; and displays of terrain and cultural objects. Conversion of terrain data was accomplished by (a) filling an area of interest completely with nonoverlapping triangles; which required (b) decisions regarding expanding particular triangles vs constructing others; (c) monitoring the results of (a) and (b) for parameter adjustments and to assure quality; (d) eliminating edges which do not help define the terrain; and (e) editing final data. Programs and subroutines needed to accomplish (a) and (b) were described and criteria used for (b) explained. Occasional mention was made of data compression which was needed to reduce the volume of data, but the techniques employed were not clearly identified. The brief treatment of cultural data conversion revealed only that NAVTRAEQUIPCEN data were adapted to DRLMS utilization in three "phases" (steps) and most desired reflective features could be extracted. A manually generated "edit list" could specify modifications of the result by region, sequence number, parameter, and type. A flow chart accompanying the discussion of cultural conversion aids in understanding the structure of the conversion, but not its nature. Display of terrain and cultural objects required a program to extract relevant information, process it appropriately, and generate element intensities. Five subprograms needed for the first two were described as were two that accomplished the third and the eventual hardware display.

Key Number

6 AUTHOR'S CONCLUSIONS:
"Terrain (elevation) data compression required judgment which is difficult to program." The present effort produced "possible results, but further refinement is desirable." "Programs for cultural data proved to be surprisingly complex," and "Manual intervention is needed to correct errors . . . Simulation of the special-purpose hardware with the general-purpose Sigma 7 is so slow as to require separation of the several phases of display processing." Nevertheless, the "feasibility of producing General Electric terrain data from TOPOCOM (not defined) data" was demonstrated.

7 EVALUATION:
This report was difficult to follow. While terrain data conversion received lengthy treatment, it was often difficult to discern what the author intended to convey. A sentence describing a component was frequently followed by one stating a criterion for a computer decision, and often the connection between the two was unclear. In his conclusions, the author referred to the difficulty in constructing programs for cultural data conversions but these complexities were not identified in the overly brief discussion of the programs. Syntactical lapses rendered a few key statements uninterpretable. Flow diagrams were especially helpful, however, for they at least revealed the structure of the programming. Thus the report made some contribution to understanding how the DRLMS could be used in radar landmass simulation.

22 SYSTEM/CLASS:
Radar landmass simulation

24 NUMBER OF PAGES:
0035

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Structural analysis

32 DESCRIPTIVE NOTES:
Final report

36 REPORT TITLE:
Simulation of a Digital Radar Landmass Simulator

Key Number

37 REPORT AUTHOR:
Derby, R.M.

38 REPORT DATE:
73/01/00

40 ORIGINATING ACTIVITY:
Apollo and Ground Systems, General Electric Company, Daytona Beach, Florida

44 CONTRACT/PROJECT/TASK:
N61339-71-C-0207/1743-01

48 REPORT NUMBER:
NAVTRAEQUIPCEN 71-C-0207-2

49 OTHER REPORT NUMBER:
H81 0002

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 054
28 February 1978

Key Number

1 ACCESSION NUMBER: AD- 700 375

4 CITATION:
Schumacker, R.A.; Brand, B.; Gilliland, M.G.; Sharp, W.H. Study for Applying Computer-Generated Images to Visual Simulation. Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-69-14, September, 1969.

5 ABSTRACT:
PURPOSE: This report described results of a system design study of applications of digital image generation (DIG) techniques to visual simulation.
SUMMARY: The image generating capability of the DIG system must accommodate: (a) day and night circling approaches, takeoffs, and landings; (b) day and night taxiing; (c) formation flying; (d) air-to-air combat; (e) aerobatic maneuvers; and (f) air-to-ground weapons delivery. Necessary for these accommodations are a 500-edge object generating capability for a single cockpit. For two cockpits, assuming that each is modeled with 150 edges and the remaining capabilities are used for terrain, environment storage must provide for 650-edge complexity. Each view should have a textured surface generator for providing images on one plane surface. Furthermore, point-source generators must provide capability for displaying at least 500 light-source images. Also, "modest" air-to-ground weapons effects (tracer fire, one or two missiles in flight) must be provided for in reserve computing capability. Finally, the sky should be represented by a solid background color. The DIG system, which is compatible with standard television equipment, was then described. Objects are generated first as a display of plane images of individual polygons. A detailed mathematical discussion described how these polygons acquire perspective and convex shape. Because of the large amount of vector arithmetic required, special purpose arithmetic units must be employed. Surface generation was developed next and its geometry illustrated. The ground plane information is stored as maps and patterns are defined by storing colors in memory locations corresponding to cells of the plane. Point-source generation, a relatively easy problem, was described with all vectors expressed in display coordinates. The overall system configuration was then presented as a flow chart. System parameters were: (a) the field of view, controlled by a numerical constant, with a working range of 45 to 120 degrees, either as width or height; (b) a 1023-line display with frame

Key Number

rate of 30 fps, interlace of 2.1, 1000 nominal active lines and elements, 27 microseconds active line time, and 4 MHz video clock rate; (c) a coordinate system for each cockpit in addition to that for the ground; (d) a translational range of plus or minus 175 miles, altitude zero to 20 miles, and a least-increment resolution of .03 feet; (e) an all digital interface to provide a complete set of inputs once per frame; and (f) an output interface providing color signals on 92-ohm coaxial cable with a nominal amplitude of 3 volts peak-to-peak. At this point the difficult problem of "priority," or interposition of objects, arises. In the completely general case computations increase exponentially with the number of objects. The NASA-2 matrix system was one direct solution but both hardware complexity and associated computations increased as the square of the number of objects. A priority list technique had been devised that required only the finding of a list of length N instead of a matrix of size N square. No part of a listed object with a given priority could be hidden by a object lower on the list, but any object with higher priority would take precedence over it. However, in such linear arrangements objects must be represented by a sufficient number of nonoverlapping polygons so that selected parts of objects rather than their entireties can be prioritized. A mathematically rigorous development of two rules for such detailed prioritization was given, using an N-square matrix as a starting point. (The rules can be applied without involving a matrix, however.) The rules stated that every subset of three objects must either (a) be separated by two planes, or (b) be in a star formation. To accomplish the simulation outlined, real-time computation must: (a) accept flight dynamics inputs from a problem computer; (b) calculate position and attitude of two aircraft; (c) transform coordinates of various vectors to object and ground systems; (d) perform tests to establish potential visibility of faces; (e) compute a priority list; (f) compute initial values for a surface generating subsystem; (g) compute point source image coordinates; (h) compute air-to-ground weapons' trajectories and effects; and (i) transmit data to image generating subsystems. Off-line tasks required to construct new environments included: accepting and storing vertex, face, and color data; testing data for proper format and consistency; assisting in establishing and testing priority lists; formatting and encoding data; and assembling operating programs. Requirements for the general purpose computer were: (a) binary word length of 30 bits; (b) memory cycle time of one microsecond (ms); (c) two general purpose hardware index registers; (d) four quadrant hardware multiply and divide (fixed point) with 10ms multiply and 20ms divide; (e) direct addressing of entire core memory; (f) indirect addressing with post-indexing capability; (g) immediate addressing of operands; (h) logical and comparison instructions; (i) shift operations on single and double words;

Key Number

(j) direct input/output channel; (k) multiple port memory configuration; and (l) list processing instructions.

7 EVALUATION:
This report was almost nine years old at the time of this abstract (1978) but its contents are still of considerable value to anyone concerned with visual simulation. Even though computer capabilities and software techniques have advanced since 1969, the thoroughness and rigor of the systems study yielded parameters and guides which are still applicable. The report was long and mathematically technical. However, few words were wasted and the organizational and writing skills of the authors assured a readable product.

10 AUTHOR'S RESEARCH SUGGESTIONS:
Regarding scene statistics, "it is important to determine the factors that specify the length of the loading queue and the upper limit on the number of faces that must be loaded during a raster line period . . . (another) step that should be taken involves conferring with Texas Instruments on the implementaion of specific logic functions, in order that the options in logic design are chosen such that the LSI implementation of the function is simplified . . . (a) survey of semiconductor industry capabilities should be continued . . . in order to assess the progress of the expected technological advances . . ." With respect to priority lists, "Further investigation is needed to (1) detail the list-forming algorithm, (2) provide computer-assisted environmental design, and (3) find methods of working with more complex memory objects situations."

22 SYSTEM/CLASS:
Visual simulation

24 NUMBER OF PAGES:
0131

25 NUMBER OF REFERENCES:
0002

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Mathematical derivation

32 DESCRIPTIVE NOTES:
Final Report (January 1969 - July 1969)

Key Number

36 REPORT TITLE:
Study for Applying Computer-Generated Images to Visual Simulation

37 REPORT AUTHOR:
Schumacker, R.A.; Brand, B.; Gilliland, M.G.; Sharp, W.H.

38 REPORT DATE:
69/09/00

40 ORIGINATING ACTIVITY:
Apollo Systems, General Electric Company, Daytona Beach, Florida

44 CONTRACT/PROJECT/TASK:
F33615-69-C-1280/6114

48 REPORT NUMBER:
AFHRL-TR-69-14

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 055
28 February 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Booker, J.K.; Golovcsenko, I.V. Instructor Console Instrument Simulation (Interim Report). Naval Training Device Center, Orlando, Florida, NAVTRAEQUIPCEN IH-195, June, 1971.

5 ABSTRACT:
PURPOSE: The purpose of study "was to duplicate the functions of the present TRADEC F4E instructor console on the inhouse computer generated display system . . . (and) to develop a display system executive program to provide for interactive control of display formats."
SUMMARY: A program to construct stationary dials was written which calculated coordinates of short vectors from input parameters for inner and outer radii and for the angle increment between vectors. A subroutine calculated needle position for certain instruments from inputs of angle of pointer to a zero degree reference and the pointer's length. When needed for a particular instrument, an additional program determined supplementary information. For example, an altimeter requires not only a pointer position but a 1000 ft counter which is activated with each complete revolution of the pointer. Hence a program must access counter information in memory and display it along with pointer positions. Artificial horizon was simulated by a program which (a) calculated coordinates of a straight-line vector representing the horizon bar; (b) eliminated those portions outside the circular viewing area; (c) computed vectors showing the up/down sense of the aircraft; (d) calculated (and blanked out as appropriate) instantaneous coordinate positions of two 90-degree circles appearing at plus or minus 90 degrees on the pitch reference scale; and (f) determined aircraft roll and pitch. The mathematics underlying these geometric relations were presented at some length. Only the altimeter and gyro horizon instrument simulations were discussed. As for other instruments the authors simply stated that "As of the date of this report, the following instruments have been completed: altimeter, gyro horizon, left . . . (and) right engine fuel flow, gyro compass, angle of attack, stabilator trim, turn and slip indicator, right engine exhaust nozzle position indicator, left . . . (and) right engine exhaust gas temperature, left . . . (and) right engine tacometer, fuel quantity indicator, and the rate of climb indicator." Only two instruments, the normal acceleration and mach indicators,

Key Number

remained to be simulated in order to complete individual simulation of all instruments on the F4E instructor's console. Interactive control of display formats from two instructor consoles was accomplished by an easily modified program which provided for pushbutton selection of the refresh mode, and build, delete, and select modes for instruments and fixed groups of instruments. The instructor can select either a synchronous or asynchronous refresh rate.

7 EVALUATION:
This interim report is obviously incomplete: Only two of 17 completed instrument simulations were discussed. These discussions were reasonably complete, however, and showed evidence of careful logical development. No program information per se was provided for these simulations or for the executive program which permitted the instructor to interact with the system. Hence a reader may learn what was accomplished but not how.

22 SYSTEM/CLASS:
Instructor console/instrument simulation

24 NUMBER OF PAGES:
0036

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description

32 DESCRIPTIVE NOTES:
Interim Report - May 1970 - June 1971

36 REPORT TITLE:
Instructor Console Instrument Simulation (Interim Report)

37 REPORT AUTHOR:
Booker, J.L.; Golovcsenko, I.V.

38 REPORT DATE:
71/06/00

40 ORIGINATING ACTIVITY:
Naval Training Device Center, Orlando, Florida

Key Number	
44	CONTRACT/PROJECT/TASK: NAVTRADEVCEN Task No. 7884-27
48	REPORT NUMBER: NAVTRADEVCEN IH-195
52	PUBLISHER/SPONSOR: Naval Training Device Center, Orlando, Florida
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 056
2 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Derderian, G. Optical Relationships for Visual Simulation Systems. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN IH-235, May, 1974.

5 ABSTRACT:
PURPOSE: There are three basic optical characteristics of visual simulation systems, field of view (FOV), exit pupil diameter, and viewing distance. The purpose of this study was to analyze geometrically a direct refractive and internal image relay display system as these systems relate to the basic characteristics.
SUMMARY: "A direct type of display system consists merely of the object to be viewed, located at the primary focal plane of the collimating element . . . If it were required to view a secondary scene within the same field of view, a beam splitter would be placed between the collimating element and the exit pupil . . . (resulting) in superimposed fields of view." (The beam splitter is omitted in the mathematical development.) The diameter of the collimator is shown to equal two times the viewing distance, multiplied by the tangent of half the angle of FOV, with the exit pupil diameter added to this product. The maximum object diameter (OD) which may be in FOV was readily determined to equal twice the collimator focal length times the tangent of half the angle of FOV. While in general it is desirable to keep OD at a minimum, a limiting factor is its dependence on collimator focal length, which in turn cannot easily be made less than the collimator diameter. Relay image displays permit use of relatively small ODs and they may be projected from a remote position. For these displays, collimator diameter was determined as above, and the image diameter (ID) had the same equation form as given above for OD. However, constraints in the image relay display required an adjustment for OD as determined by the optical characteristics of only the direct refractive display: OD equals ID times the ratio of distance between entrance pupil and collimator to the viewing distance. Hence, one may choose an OD according to ID, collimator characteristics, and viewing distance. These analyses apply to Gaussian optics conditions, and may be expanded for wide FOV applications.

Key Number

7 EVALUATION:
This report is valuable for determining the characteristics of optical components of visual simulation systems. The article is succinct, perhaps too much so for easy reading. The reader is expected to examine complex three-dimensional representations and "see" that certain functions follow. The mathematics are elementary nevertheless, and may be followed without undue difficulty.

8 COMMENTS:
This report was dated as May 1974 on the Report Documentation Page, but as June 1974 on the cover page.

22 SYSTEM/CLASS:
Visual simulation

24 NUMBER OF PAGES:
0007

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Mathematical derivation

36 REPORT TITLE:
Optical Relationships for Visual Simulation Systems

37 REPORT AUTHOR:
Derderian, G.

38 REPORT DATE:
74/05/00

40 ORIGINATING ACTIVITY:
Physical Science Laboratory, N-211, Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
Project 3717-02

48 REPORT NUMBER:
NAVTRAEQUIPCEN IH-235

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

Key Number

56 TYPE OF PUBLICATION:
In-house report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 057
2 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Gabriel, R.F.; Burrows, A.A.; Abbott, P.E. Using a Generalized Contact Flight Simulator to Improve Visual Time Sharing. Naval Training Device Center, Port Washington, New York, NAVTRADEVCEN TR-1428-1, April, 1965.

5 ABSTRACT:
PURPOSE: The purposes of this experiment were stated as four questions: (a) Does training in time sharing improve visual performance of pilots of single-seat, high performance aircraft? (b) Does such training in one mode of flight transfer to other modes? (c) Does previous flight experience affect time-sharing performance? (d) Can a single generalized trainer be used for teaching time sharing?
METHOD: Thirty Ss, each with fewer than 500 hours of total flight time, and 30 with more than 500 hours, were randomly drawn from a larger pool of unstated size. Half of each group were then assigned randomly to an experimental group (E) with the remaining Ss being placed in a control group (C). E Ss received one-half day training during each of 8 successive weeks, with the first and part of the second session devoted to flying an unidentified training simulator while various (unstated) stimuli were presented. During the second part of session 2, training to speed-read instruments was begun. During each of the remaining 6 sessions the S flew the trainer for approximately one hour and practiced speed-reading for a half hour. During session 2 a mean time per glance at the instrument panel, and a mean time between glances, were established for each S. On flights during sessions 3 - 8, the pilot's instrument scan time was controlled by programming panel lights to go on and off at rates beginning with the S's session 2 baseline data, but with time permitted per glance decreasing with each successive session and time between glances increasing. During each flight the S flew 5 - 10 minutes without assigned tasks, after which he trained on a navigation-cruise phase (NC) and a glide-bombing phase (GB), except that instead of GB training during sessions 5 and 8, each S was instructed to maintain a heading and detect various (unstated) stimuli while instrument lights were burning continuously and while they were controlled by a program as above. Speed-reading training was conducted by projecting images of various instruments on a backlit screen, with exposure time systematically

Key Number

reduced within and with successive sessions. Criterion data were then collected for E and C from single flights in an A4D-2N Operational Flight Trainer. The criterion flight had four phases: NC and GB as during E training, and climbout (CO) and penetration (PEN). A randomized program determined when extra-cockpit (intruders) and cockpit (simulated instrument malfunctions) emergencies would occur during each phase. Measures obtained during each phase were (a) numbers of detections of front and of side intruders, and of instrument malfunctions; (b) time required for each detection; and (c) tracking performance in heading and altitude.
RESULTS: Using a criterion of emergency detection in ten seconds or less, E detected 68 per cent of front intruders while C detected only 29 per cent. A Wilson's distribution-free test ANOVA yielded p .LT. .005 for this difference, but no significance for experience level or training by level interaction, implying training was effective for more as well as less experienced Ss. No significant differences of per cent detections were found, however, for side intruders or instrument malfunctions. Mean detection times for front intruders were significantly lower (p .LT. .005) for E but training had no significant effect for side intruders or instrument malfunctions. However, flight phase detection times differed for side intruders and instrument malfunctions (p .LT. .005) with NC and CO times generally greater than those for PEN for both emergencies. (BG times were not included in these analyses.) No significant effects were found for heading accuracy, and only the phase effect was significant (p .LT. .005) for altitude maintenance, with NC errors less than those for CO and PEN.

6 AUTHOR'S CONCLUSIONS:
(a) The training provided E Ss "was highly effective in developing improved time sharing patterns"; (b) training resulted in a marked improvement in detection of front intruders; (c) tachistoscopic projection is valuable for training speed-reading; (d) time sharing training was effective for Ss of both high and low experience levels; and (e) such training transfers from one flight "regime" (phase?) to another.

7 EVALUATION:
This was a well designed and carefully executed study. However, conclusions as stated generally do not follow. The only data supporting conclusion (a) are curves revealing zero, slight, and one moderate improvement in emergency detection during training, and no significance data were reported for the improvements. No data at all were provided in support of conclusion (c), and (d) holds only for those instances in which training had an effect, i.e., detection rate and time for front intruders. (Detection rate for side intruders may have been

Key Number

too high for both E and C, 97 and 94 per cent, respectively, for a significant difference to occur, but this is not true of instrument malfunctions.) Conclusion (e) has partial support in that the superiority of E for per cent detections of front intruders appeared to hold for CO and PEN as well as NC. No separate significance tests for phases were reported, however, and the authors' statement that no significant differences were found among phases for mean detection time for front intruders was not supported by a statistical test in the report. Even so, examination of means reveals that performance on the training phase NC was poorer than either nontraining phase PEN or CO! Furthermore, the clinching reductio ad absurdum contra conclusion (e) is found in those three ANOVAS for which phase was a significant effect. Training did not even approach significance, and performance during the trained phase NC was considerably inferior to that for the nontrained phase PEN, and comparable to CO, for both side intruders and instrument malfunctions. For altitude error NC, data showed lower means than PEN and CO data, but for both E and C. (The F for the E-C difference was 0.12). To support conclusion (e), the unacceptable inference from these three ANOVAS would have to be that, in spite of no training effects, training transferred anyway, and the transfer effect was greater to an untrained phase than the training effect was to a trained phase. A more likely explanation for the typical superiority of both E and C performance on PEN is that this phase is less demanding of a S's attention, thus permitting more attendance to emergency cues. To test properly for transfer, therefore, phases should be counterbalanced in training and as transfer conditions, with each phase serving both roles. In spite of these negative comments, the study has merit. As stated in conclusion (b), the training in time sharing and/or speed reading apparently improved detection of front intruders, and possibly transferred to nontrained phases. A second value of the study is that it points to a possible need for better training in time sharing than was available at the time of the study.

14 DEPENDENT VARIABLES:

Per cent detection of front intruders, side intruders, and instrument malfunctions; time required to detect these emergencies; tracking heading errors; tracking altitude errors

15 INDEPENDENT VARIABLES:

Training vs no training in time sharing; training vs no training in instrument speed reading; .LT. or .GT. 500 hours flight experience

16 MEASUREMENT/STATISTICAL METHODS:

Wilson's distribution-free ANOVA; ANOVA

Key Number

20 APPARATUS/MEDIA USED:
Tachistoscope

22 SYSTEM/CLASS:
Aircraft cockpit simulator

23 SUBJECT POOL:
Pilots with fewer than and more than 500 hours flight experience

24 NUMBER OF PAGES:
0073

25 NUMBER OF REFERENCES:
0019

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Using a Generalized Contact Flight Simulator to Improve Visual Time Sharing

37 REPORT AUTHOR:
Gabriel, R.F.; Burrows, A.A.; Abbott, P.E.

38 REPORT DATE:
65/04/00

40 ORIGINATING ACTIVITY:
Douglas Aircraft Company, Long Beach, California

48 REPORT NUMBER:
NAVTRADEVCEN-1428-1

52 PUBLISHER/SPONSOR:
Naval Training Device Center, Port Washington, New York

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

Key Number

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 058
3 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Barnes, J.A. Tactical Utility Helicopter Information Transfer Study. Human Engineering Laboratories, Aberdeen Research and Development Center, Aberdeen Proving Ground, Maryland, Technical Memorandum 7-70, March, 1970.

5 ABSTRACT:

PURPOSE: The purpose of this study was to determine analytically the information needs of the flight crews of a tactical utility helicopter which could be satisfied by basic flight instrumentation.
METHOD: Eleven Ss current in the UH-1 helicopter, and with from 1,000 - 10,000 hours of rotary wing experience, provided information through questionnaires and interviews regarding instrument use for each of 96 tasks involved in helicopter missions. From the information provided, 21 tasks with high instrument usage were selected to be performed in an unstated number of actual utility transport, rescue, and fire support missions. During these missions an eye-movement camera recorded the pilots' eye fixations on instruments and their durations. Data for the following instruments were recorded: (a) attitude indicators; (b) altimeter; (c) airspeed indicator; (d) compass; (e) vertical velocity; (f) rate of turn; (g) torque meter; (h) dual tachometer; (i) and engine instruments.
RESULTS: Data were reported for per cents of time pilots used these instruments while performing the 21 tasks in actual flight. As summarized below, total instrument per cents are given, and unless indicated, per cents did not vary appreciably from one instrument to another. The difference between total per cents as given and 100 was the proportion of time the pilot used extracockpit references. For spot hover in ground effect (IGE), visual, 15%; spot hover IGE, instruments, 100%; spot out of ground effect (OGE), 100%; 360 degree hovering turn OGE, 62% with little use of instruments (d)-(i); vertical climb, 100% with emphasis on (a), (b), and (e); vertical descent, 25%; cruise at 60K, visual, 52%; cruise at 60K, instruments, 100% with little use of (f); standard rate of turn, 60K, 100% with emphasis on (a) and (b); climb, 60K and 500 FPM, 100%; climb from hover, 85%; initial descent to 500 ft, 60K, 100% with no use of (f); reverse direction of flight, 60K, 100%, emphasizing (a), (b), and (d); cruise 100K, visual, 52%; cruise 100K, instruments, 100% with little use of (f)-(i); standard rate of

Key Number

turn, 100K, 100% emphasizing (b) and (d); terrain following, 100K, 15%; climb 100K, 500 FPM, 100%; descent, 100K, 500 FPM, 100% with little use of (f)-(i); 180 degree descending, look, 97% with little use of (f)-(i); reverse direction, 100K, 100% emphasizing (a), (b), (d), and (e). Generally, fixation rested in the center of the instrument panel, and most scanning occurred along a horizontal center line of the panel.

7 EVALUATION:
This study identified basic flight instrument information a UH-1 pilot believed he needed and what he used. No comparison of subjective and objective data were reported, however. Tabular information suggested a low correlation between these data, which implies that subjective data of this nature may be misleading.

14 DEPENDENT VARIABLES:
Per cent of time pilots fixate on flight instruments

22 SYSTEM/CLASS:
UH-1 helicopter

24 NUMBER OF PAGES:
0096

25 NUMBER OF REFERENCES:
0013

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Informal experiment

36 REPORT TITLE:
Tactical Utility Helicopter Information Transfer Study

37 REPORT AUTHOR:
Barnes, J.A.

38 REPORT DATE:
70/03/00

40 ORIGINATING ACTIVITY:
Human Engineering Laboratories, Aberdeen Proving Ground, Maryland

48 REPORT NUMBER:
Technical memorandum 7-70

Key Number

52 PUBLISHER/SPONSOR:
Aberdeen Research and Development Center, Aberdeen Proving Ground, Maryland

56 TYPE OF PUBLICATION:
Technical memorandum

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 059
3 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Ince, F.; Williges, R.C.; Roscoe, S.N. Aircraft Simulator Motion and the Order of Merit of Flight Attitude and Steering Guidance Displays. Air Force Office of Scientific Research, Arlington, Virginia, AFOSR-TR-74-1348, October, 1973.

5 ABSTRACT:
PURPOSE: The purpose of this study was to replicate the Roscoe & Williges (1973) flight study in the Link GAT-2 simulator with cockpit motion as an experimental variable.
METHOD: Ss were 24 male nonpilot, volunteer, university students 18-26 years of age, with 8 Ss randomly assigned to each of three groups: no motion; standard Link GAT-2 motion; and washout motion. The GAT-2 had cockpit controls, flight response dynamics, and instrument indicators similar to a light twin-engine aircraft. A Raytheon 704 was connected to the simulator to drive the display and record the variables. The pilots primary display panel was a Tektronix 604 rectangular CRT. The experimenter controlled the simulator from a console located in the control instrument panel. Three experimental tasks were used: disturbed attitude tracking (DAT) in which Ss had to compensate for arbitrary but standard forcing functions; command flight path tracking (FPT) in which Ss were required to follow random horizontal turn commands; and recovery from unknown attitudes (RUA) inserted by the experimenter. Displays for moving horizon, moving airplane, and frequency-separated aileron attitude were used for all three tasks, and kinalog display for DAT and FPT. Ten variables were recorded: (a) pitch, (b) angle bank, (c) angle roll, (d) total forcing functions, (e) high frequency portion of forcing function, (f) aileron angle, (g) sine of bank angle, (h) horizontal tracking angle, (i) coded display format, and (j) state of a tapping switch located on the control yoke.
RESULTS: DAT, as measured by a log transform of the root mean square of banking attitude error, improved reliably from first trials to second trials across all displays (F = 8.6, p .LT. .01) and from first to second to third segments within trials (F = 48.5, p .LT. .001). The standard motion and the washout motion resulted in better overall performance (F = 4.92, p .LT. .05). Pilot performance was affected by the type display used (F = 18.0, p .LT. .001). FPT was measured as a root mean square of horizontal steering error. A significant interaction

Key Number

between display type and tracking mode (compensatory vs. pursuit) was obtained (F = 3.32, p .LT. .05), with moving horizon display giving the poorest performance of all with the pursuit mode, and best of all with the compensatory mode. Motion mode by trial segment interaction was also significant (F = 4.00, p .LT. .01), with standard GAT-2 motion producing poor performance in the first flight, and especially when flying with the moving horizon display in pursuit tracking. RUA was measured as proportion of control reversals in recovery from unknown attitudes and mean time to recover. No significance tests were reported for the former, but for mean time the frequency separated display yielded results superior to those for moving horizon and moving airplane. Speed of recovery also improved generally over trials.

6 AUTHOR'S CONCLUSIONS:
"This investigation of the effects of variations in flight simulator motion dynamics upon the order of merit of a family of flight displays provides additional evidence that the outcome of human engineering experiments in simulators can depend upon the motion system employed."

7 EVALUATION:
This was a short, concise, well-organized and well-written article which described a carefully controlled experiment. It addressed the problem squarely and showed statistically that the addition of motion affected simulator performance.

14 DEPENDENT VARIABLES:
Root mean square (RMS) banking error for disturbed attitude tracking; RMS for azimuth steering error; number of control reversals during recovery, and mean time to recover, from unknown attitudes

15 INDEPENDENT VARIABLES:
Simulator motion; type of display (moving horizon, moving airplane, frequency separated aileron position, kinalog); tracking mode

16 MEASUREMENT/STATISTICAL METHODS:
ANOVA

22 SYSTEM/CLASS:
GAT-2 flight simulator

23 SUBJECT POOL:
Male nonpilot volunteer college students 18-26 years of age

Key Number

24 NUMBER OF PAGES:
0009

25 NUMBER OF REFERENCES:
0021

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

32 DESCRIPTIVE NOTES:
Scientific Interim

33 SUPPLEMENTARY NOTES:
Proceedings of the 17th Annual Meeting of the Human Factors Society, Washington, D.C., 16-18 October, 1973

36 REPORT TITLE:
Aircraft Simulator Motion and the Order of Merit of Flight Attitude and Steering Guidance Displays

37 REPORT AUTHOR:
Ince, F.; Williges, R.C.; Roscoe, S.N.

38 REPORT DATE:
73/10/00

40 ORIGINATING ACTIVITY:
Aviation Research Laboratory, University of Illinois, Urbana-Champaign, Illinois

44 CONTRACT/PROJECT/TASK:
F44620-70-C-0105/9778/61120F/681313

48 REPORT NUMBER:
AFOSR-TR-74-1348

52 PUBLISHER/SPONSOR:
Air Force Office of Scientific Research, Arlington, Virginia

56 TYPE OF PUBLICATION:
Scientific interim report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

059-3

Key Number

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

059-4

ABSTRACT 060
3 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Gabriel, R.F.; Burrows, A.A.; Abbott, P.E. Eye Accommodation Time Experiment (Appendix B of Using a Generalized Contact Flight Simulator to Improve Visual Time Sharing). Naval Training Device Center, Port Washington, New York, NAVTRADEVCEN TR-1428-1, April, 1965.

5 ABSTRACT:

PURPOSE: The purpose of this study was to determine the time required for a pilot to accommodate visually to various flight instruments.
METHOD: Ten Marine A4 pilots and two civilian pilots with comparable flight experience served as Ss. Using a two-channel tachistoscope, each S viewed a Landolt C ring, and upon recognizing the location of the gap, stated its location into a microphone. A voice-actuated relay immediately turned on a slide projector which showed an image of an aircraft instrument. Ss were instructed to read the instrument value displayed aloud as soon as possible, whereupon the voice actuated relay stopped the image projection. The visual angle was one minute of arc for the C ring. The instruments displayed were an airspeed indicator (ASI), compass (COM), attitude indicator (AI), turn and slip indicator (TSI), three-pointer altimeter (ALT), and a rate of climb indicator (RCI). Ss practiced to asymptotic level before data were collected. The dependent measure was time in seconds required to read a given instrument after viewing C rings.
RESULTS: Mean times in seconds required to read each instrument (and their standard deviations) were: ASI, 1.49 (.23); COM, 1.59 (.28); AI, 1.54 (.24); TSI, 1.61 (.14); ALT, 1.31 (.12); and RCI, 1.35 (.20)

7 EVALUATION:
In its brevity this report did not give enough information to ensure a reader that adequate controls of head position, viewing distance, etc., were maintained. Nevertheless, the procedure is relatively uncomplicated and thus not difficult to instrument. As the authors pointed out, the laboratory conditions under which these tests were made were quite different from those in an aircraft. However, laboratory data of this sort are needed to establish relative bases for generalizations. The generalizations themselves must incorporate

Key Number

parameters of lighting conditions, time sharing, etc., characteristic of flight.

8 COMMENTS:
This study was reported as Appendix B of the article identified in the citation. It was abstracted separately because its purpose and nature were different from the purpose and nature of the parent study, and its retrieval would have been difficult if it had been subsumed under the parent study.

14 DEPENDENT VARIABLES:
Time required to read projected images of an airspeed indicator, compass, attitude indicator, turn and slip indicator, three-pointer altimeter, rate of climb indicator

20 APPARATUS/MEDIA USED:
Two-channel tachistoscope

23 SUBJECT POOL:
Marine A4 and civilian pilots

24 NUMBER OF PAGES:
0004

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

36 REPORT TITLE:
Eye Accommodation Time Experiment (Appendix B of Using a Generalized Contact Flight Simulator to Improve Visual Time Sharing)

37 REPORT AUTHOR:
Gabriel, R.F.; Burrows, A.A.; Abbott, P.E.

38 REPORT DATE:
65/04/00

40 ORIGINATING ACTIVITY:
Douglas Aircraft Company, Long Beach, California

48 REPORT NUMBER:
NAVTRADEVCEN - 1428-1

Key Number

52 PUBLISHER/SPONSOR:
Naval Training Device Center, Port Washington, New York

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 061
3 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Dowd, P.J. A Critical Assessment of Ground Based Devices for Spatial Orientation Training. US Air Force School of Aerospace Medicine, Brooks Air Force Base, Texas, SAM-TR-73-23, August, 1973.

5 ABSTRACT:

PURPOSE: The purpose of this study was to make comparisons of selected orientation training devices in relation to United States Air Force flight training in T-38's, to assess ground-based device capabilities to generate spatial disorienting illusions, and to verify that current flight training has need for such devices.

SUMMARY: Proposed areas of comparisons were: (a) motion parameters; (b) generated illusions; (c) types of instrumentation available; (d) the pilot's reaction capability to recover from disorienting illusions; (e) the pilot's coping performance in dealing with disorienting maneuvers; (f) the training simulator's invulnerability to weather; (g) safety; and (h) initial and operating expenses. The criteria for assessment were: (a) similarity of trainer illusion to those normally occurring in actual flight; (b) reproducibility of trainer illusions; (c) recovery capabilities of the trainer; (d) training capabilities; (e) safety; and (f) cost. Five one degree-of-freedom devices were identified which produce Coriolis acceleration illusions: the Barany chair; the Civil Aeromedical Institute (CAMI) disorientation device; the Vertigon; the modified Link trainer, and the USAF School of Aerospace Medicine (USAFSAM) processional rotation device (PRD). The USAFSAM biaxial simulator can induce passive Coriolis by tilting in the sagittal plane. More spatially disorienting illusions are possible with a centrifuge, but their costs made them prohibitive for general use. The Burtek USAFSAM spatial disorientation device (SDD) provided a better illusion, but as of this report it had been untested, and the subject had no active control of the device. The USAFSAM spatial orientation trainer (SOT) was the best device by virtue of its full spectrum of illusions, and provisions for pilots' active participation, pilots' learning by doing, and repeatability of tasks.

Key Number

6 AUTHOR'S CONCLUSIONS:
"A spatial orientation trainer is only a partial solution . . . It needs to be carefully inserted in a well-researched and organized training program . . . It is less costly and infinitely better to train the pilot to cope with spatial disorienting flight maneuvers than to replace him."

7 EVALUATION:
The author stated worthy purposes and defined an excellent study by identifying devices to be compared, areas for comparisons, and criteria therefor. However, only brief discussions and of only some devices were presented, and some stated areas for comparisons were omitted entirely. There was no evidence of systematic use of criteria nor was there a recognizable methodology. Hence, a reader cannot satisfy himself that results reported in a summary table are valid.

10 AUTHOR'S RESEARCH SUGGESTIONS:
Flight training commands and the special AGARD Ad Hoc Working Group on Spatial Orientation can investigate SOT's by: (a) parallel tests with and without a SOT; (b) comparing aircraft and SOT disorientation effects; (c) testing transfer of training from SOT to actual aircraft; and (d) comparing cost effectiveness of SOT and actual training.

22 SYSTEM/CLASS:
Orientation training device

24 NUMBER OF PAGES:
0010

25 NUMBER OF REFERENCES:
0007

28 RESEARCH CLASS:
Status study

29 RESEARCH METHOD:
Description/evaluative

32 DESCRIPTIVE NOTES:
Preliminary Report - September 1972 to April 1973

36 REPORT TITLE:
A Critical Assessment of Ground Based Devices for Spatial Orientation Training

37 REPORT AUTHOR:
Dowd, P.J.

Key Number

38 REPORT DATE:
73/08/00

40 ORIGINATING ACTIVITY:
US Air Force School of Aerospace Medicine, Brooks Air Force Base, Texas

44 CONTRACT/PROJECT/TASK/WORK UNIT:
7930/09/01

48 REPORT NUMBER:
SAM-TR-73-23

52 PUBLISHER/SPONSOR:
US Air Force School of Aerospace Medicine, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 062
6 March 1978

Key Number
1 ACCESSION NUMBER:

4 CITATION:
Jacobs, R.S.; Williges, R.C.; Roscoe, S.N. Simulated Motion as a Factor in Flight-Director Display Evaluation. Aviation Research Laboratory, University of Illinois, Urbana-Champaign, Illinois, Technical Report ARL-72-1/ONR-72-1/AFOSR-72-1, February, 1972.

5 ABSTRACT:
PURPOSE: The purpose of this study was " ɔ investigate the interactive effects of motion cue structure with aircraft simulator results pertaining to comparisons of various flight-detector/attitude indicator displays."
METHOD: Ss were 8 male college students who held a private pilots certificate and had 40 to 150 hours flight experience. Ss flew a GAT-2 simulator with experimental instrument displays mounted on top of the instrument panel. The standard attitude display instruments were covered. Four basic modes of attitude presentation, moving horizon (MH), moving airplane (MA), kinalog (K), and frequency-separated presentation (FSP), were used with each of two steering modes, compensatory and pursuit. Two practice trials without motion were designed to allow the subject to become familiar with the dynamics of the eight displays. An evaluation task, 24 hours after the second practice task and also without motion, consisted of a three-minute trial for each display with a one-minute rest between the two 4-trial sets. The order of testing was a randomized Latin square design.
RESULTS: Data from this study were combined with data from an earlier effort (see Cross References) which used simulator motion. Analyses were conducted on the horizontal steering error performance of the evaluation task. The results of a two-way ANOVA comparing the eight displays with and without motion showed that motion resulted in smaller errors (F = 6.07, p .LT. .05). Displays differed also (F = 4.02, p .LT. .10). "A Duncan new multiple-range test revealed . . . (smaller errors for) the pursuit moving airplane configuration than (for) any of the other seven configurations" (p .LT. .05). The results of a three-way ANOVA on the attitude presentation, command steering presentation, and motion showed two main effects significant. For motion, F = F.56, p .LT. .05 with the motion condition superior. For command mode, F - 6.41, p .LT. .05 with pursuit command steering mode superior. Also significant

Key Number

were the attitude by command mode interaction ($F = 7.32$, p .LT. .01) and the three way interaction, attitude by command by motion ($F = 3.76$, p .LT. .05). The former interaction was due to small errors for pursuit-moving airplane configuration. Relatively small errors for pursuit-motion with both moving airplane and kinalog accounted for the three-way interaction.

6 AUTHOR'S CONCLUSIONS:
"Tracking performance was superior when the motion system was on . . . With the presence of simulator motion, pursuit steering interacted favorably with the moving-airplane attitude presentation, the combination being disproportionately superior to all other display combinations."

7 EVALUATION:
The study described in this report was well designed and carefully implemented. There is major difficulty in interpretation, however, because all the motion data were collected in a separate study which was not described, and the authors provided no information regarding the comparability of experimental conditions or subjects. They did point out that the Ss used in this study were atypical because of an emphasis upon instrument-referenced attitude control in their training, and that generalizations may be affected thereby. However, it was not stated whether the Ss in the earlier study were similarly atypical. Also, the authors should have come to grips with the significant three-way interaction described under Results. (The abstractor determined the source of the significant components.) What was needed was a discussion of this finding relating it to other research. The authors did well in relating the remaining significant effects to findings reported by others.

10 AUTHOR'S RESEARCH SUGGESTIONS:
Investigate the issue of whether or not results in fixed-base and moving-base simulators can be extrapolated to actual flight. Also investigate the comparison of pilot/system responses to similar forcing functions in the air and in ground-based simulators.

12 CROSS REFERENCES:
Johnson, S.L.; Williges, R.C.; Roscoe, S.N. A New Approach to Motion Relations for Flight Director Displays. Institute of Aviation, University of Illinois, Savoy, Illinois. Technical Report ARL-71-20/ONR-71-2/AFOSR-71-6, October, 1971.

14 DEPENDENT VARIABLES:
Pilots' log root-mean-square errors in azimuth steering

Key Number

15 INDEPENDENT VARIABLES:
Pursuit or compensatory command steering presentation; moving horizon, moving aircraft, or kinalog attitude presentation; simulator motion

16 MEASUREMENT/STATISTICAL METHODS:
ANOVA; Duncan new multiple range test

22 SYSTEM/CLASS:
Flight simulator/GAT-2

23 SUBJECT POOL:
Male students, holding private pilot certificate with from 40 to 150 hours flight experience; Ss in cross-referenced study not identified

24 NUMBER OF PAGES:
0026

25 NUMBER OF REFERENCES:
0010

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Simulated Motion as a Factor in Flight-Director Display Evaluation

37 REPORT AUTHOR:
Jacobs, R.S.; Williges, R.C.; Roscoe, S.N.

38 REPORT DATE:
72/02/00

40 ORIGINATING ACTIVITY:
Aviation Research Laboratory, University of Illinois at Urbana-Champaign

44 CONTRACT/PROJECT/TASK:
N00014-67-A-0305-0014 and F44620-70-C-0105/NR 196-092

48 REPORT NUMBER:
ARL-72-1/ONR-72-1/AFOSR-72-1

Key Number

52 PUBLISHER/SPONSOR:
Institute of Aviation, University of Illinois - Willard Airport, Savoy, Illinois

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 063
8 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Brown, J.L. Visual Elements in Flight Simulation. AVIATION SPACE AND ENVIRONMENTAL MEDICINE, 47(9), 913-924, 1976.

5 ABSTRACT:
PURPOSE: THe purpose of the report was to describe the present status of visual simulation and to suggest possible new approaches to the field.
SUMMARY: Techniques for visual simulation were discussed briefly, including projections of an image onto a screen outside the cockpit, viewing a television picture tube directly through the windscreen, and increasing the field of view in a limited space through the use of ellipsoid and spherical mirrors. Sources of visual information included a three-dimensional scale model, a model on a moving belt, transparencies or silhouettes which move in relation to a point source of illumination, photographic storage, and holographs. The advantages of electronically-generated displays (absence of mechanical components that produce time lag, unlimited terrain representations, varying perspectives) were discussed briefly as were their disadvantages which derived mostly from limitations on number of scan lines and raster lines. While the general approach had been to make the simulated visual field as large as possible, studies had shown that limiting the visual field to around 20 degrees may be accompanied by only a slight degradation in performance. Information processing by the visual system was claimed to depend upon the spatial distribution of relative luminance information and not upon absolute levels. Color was judged to be appropriate in those circumstances where important information was encoded in color variations, and for increasing pilot acceptance of a simulation device. The spatial resolution capability of simulations was recognized as far less than that of the human visual system. The resolution of a television monitor seen through a collimating system was better, cheaper, and more preferred by pilots than that of a projection system. A model built on a 600:1 scale as compared to older models on a 1200:1 scale had greatly improved resolution. The depth of field was predicted to improve with the use of more sensitive pick-up tubes and higher levels of illumination. While loss of visibility due to fog and rain had been simulated, the effects of the accumulation of bugs on the wind screen needed further attention. Motion

Key Number

information relies on precise timing of pattern changes in relation to control manipulations by the pilot. Interaction between the visual, kinesthetic, and vestibular systems is essential. Motion pictures recording control inputs and visual display response simultaneously might be used to evaluate simulator fidelity. The technique of washing out motion had been successful.

6 AUTHOR'S CONCLUSIONS:
The fact that "pilot performance is improved by motion simulation but is better on instruments than on the outside visual simulation would seem to support the contention that the visual simulation is faulty." "Although simulators are different and will remain different from aircraft, they appear to have proven their worth for training purposes as measured by time and money saved in qualifying pilots in new aircraft types." Much more research is needed to determine what visual cues are needed, what techniques should be used to present them, and how they can be evaluated most effectively.

7 EVALUATION:
Only brief discussions were provided for many subtopics but they are valuable nevertheless as a summary of the state-of-the-art in visual simulation at the time. However, the reader should already be quite familiar with the area if much is to be derived. Also, the assumption that high fidelity of visual systems is necessary can be questioned. Perhaps most valuable are the suggestions for further research.

10 AUTHOR'S RESEARCH SUGGESTIONS:
More attention should be given to the fidelity of visual motion simulation and less to the variables of spatial resolution, luminance, and color. An attempt should be made to obtain a quantitative measure of the fidelity of visual motion simulation, most likely with the use of motion picture film recording instrument display, the visual simulation, and control manipulations simultaneously. With an electronically generated display in which the visual motion cues are known to be correct, it would be possible to evaluate the individual significance of spatial resolution, luminance, color, depth of field, and field of view. Information concerning the relative precision necessary for various dimensions of a visual simulation will lead to a decision between electronically generated and laser displays. New types of displays, particularly those employing several sources for the visual display in a single installation, should be investigated. More effort should be spent to determine what procedures a pilot employs in controlling the aircraft. More systematized procedures should be developed to obtain pilot opinion. Additional research is

Key Number

needed on thresholds for movement detection under various situations and on washout techniques. The extent to which training can be achieved with part-task simulations should be determined.

14 DEPENDENT VARIABLES:
Adequacy of visual simulation for training

22 SYSTEM/CLASS:
Visual simulation

24 NUMBER OF PAGES:
0012

25 NUMBER OF REFERENCES:
0020

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Survey/evaluative

36 REPORT TITLE:
Visual Elements in Flight Simulation

37 REPORT AUTHOR:
Brown, J.L.

38 REPORT DATE:
75/00/00

40 ORIGINATING ACTIVITY:
Center for Visual Science, University of Rochester, Rochester, New York

52 PUBLISHER/SPONSOR:
ONR Contract N00014-75-C-0406

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 064
8 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Jolley, O.B.; Caro, P.W. A Determination of Selected Costs of Flight and Synthetic Flight Training. Human Resources Research Organization, Alexandria, Virginia, 70-6, April, 1970.

5 ABSTRACT:
PURPOSE: The purpose of the report was to determine selected costs of flight and synthetic flight training.
METHOD: The relative costs of flight training and synthetic flight training during the instrument phase of the U.S. Army's Officer/Warrant Officer Rotary Wing Aviator Course (O/WORWAC) were determined from data obtained during September, 1966. Indirect costs associated with both flight and synthetic flight training during this phase, e.g., administrative costs, trainee salaries, etc., were omitted. Included were costs for aircraft and trainer, buildings and facilities, including maintenance, training personnel, contractor fee, office equipment, aircraft/trainer maintenance, trainee transportation, flight clothing and equipment, fuel, and navigation facilities. Straight-line depreciation schedules were used for equipment, buildings, and clothing.
RESULTS: The costs per hour of flight and synthetic flight training were $60.69 and $9.66, respectively, a ratio of approximately 6:1.

6 AUTHOR'S CONCLUSIONS:
Replacement of one hour of flight training with less than six hours of synthetic flight training would result in a reduction of both costs and air traffic density. Such use of synthetic flight training would need to be justified by research demonstrating the effectiveness of training received in the trainer.

7 EVALUATION:
In addition to its value in presenting the relative costs of flight and synthetic flight training during the O/WORWAC, the report is useful in describing procedures for obtaining training costs data in general. The article is concise and well-written and includes detailed computational notes in a lengthy appendix. It also identifies assumptions underlying cost analyses and bases for cost allocation.

Key Number

14 DEPENDENT VARIABLES:
Relative cost of aircraft/simulator instrument training

22 SYSTEM/CLASS:
Flight simulator

24 NUMBER OF PAGES:
0042

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

32 DESCRIPTIVE NOTES:
Technical report

33 SUPPLEMENTARY NOTES:
Work Unit ECHO, Synthetic Flight Training Program and Devices

36 REPORT TITLE:
A Determination of Selected Costs of Flight and Synthetic Flight Training

37 REPORT AUTHOR:
Jolley, O.B.; Caro, P.W.

38 REPORT DATE:
70/04/00

40 ORIGINATING ACTIVITY:
Human Resources Research Organization, Alexandria, Virginia

44 CONTRACT/PROJECT/TASK:
DAHC 19-70-C-0012/2Q062107A712

48 REPORT NUMBER:
TR 70-6

52 PUBLISHER/SPONSOR:
Human Resources Research Organization, Alexandria, Virginia

56 TYPE OF PUBLICATION:
Technical report

064-2

Key Number

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 065
8 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Mes' 'r, C.W.; Roberts, J.P. Air Combat Maneuvering Training in .mulator. PROCEEDINGS OF THE AGARD FMP/GCP SYMPOSIUM: FLIGHT SIMULATION/GUIDANCE SYSTEMS SIMULATION, October, 1975.

5 ABSTRACT:
PURPOSE: The purpose of the report was to describe and evaluate the Tactical Air Command Aerial Combat Engagement Simulation (ACES).
SUMMARY: The ACES "consist(ed) of two fully operable fighter cockpits enclosed in truncated, 16-foot diameter spherical screens . . . Overhead projectors provided each pilot with a computer-generated image of the threat aircraft, a horizon and ground plane, and the F-4E lead computing optical sight system, along with the analog range bar." In the cockpits, both equipped with functional flight controls and fire control switchology, each pilot wore a g-suit and sat on a g-seat which inflated proportionately to his maneuver load factor. The mobile instructor control console was alongside the cockpit for operation from inside or out. "It contain(ed) the engagement scene display, and control of the simulation initial conditions, pilot identification, radar lockon, data recording, replay, flight recording, video recording, operate, hold, and reset." There were extensive aural and visual firing and scoring cues. An off-line scoring system provided a data profile of each pilot's progress during one week. By also fly-- the threat aircraft, the pilot was able to gain firsthand knowledge of its capabilities and limitations. Other featu included "breaking radar lockon for the AIM-7 missile, the replay, and a capability to record 3 minutes of maneuvering flight." The cost of the program was $250 per hour per cockpit. The syllabus consisted of 17 sorties totalling 9 hours of training. Critiques completed by 208 pilots showed acceptance of the program. Performance in the simulator typically improved during one week in: (a) high-deflection cannon attack, (b) weapon envelope parameter recognition, (c) energy management, (d) gun tracking, (e) cockpit switchology, (f) basic fighter maneuvers, and (g) gunsight control. Improvement was also noted in the ability to maneuver into the ordnance envelope against a target maneuvering in a set pattern, in less time, using less fuel, energy, and ordnance.

Key Number

6 AUTHOR'S CONCLUSIONS:
The ACES program "appears to improve the typical F-4 pilot's grasp of air combat maneuvering." Experience with the program is valuable in designing future simulators and programs. After using ACES, the typical figher pilot has a more positive attitude toward simulators.

7 EVALUTION:
This report is useful in providing a brief description of a simulation system. As recognized by the authors, until objective evaluation measures are obtained, it is premature to state its value in terms other than pilot acceptance and cost savings. The report was discursive and informal, and no systematic use was made of data given in numerous figures. Also, little information was provided as to how data were collected.

14 DEPENDENT VARIABLES:
Pilot performance in high-deflection cannon attack; weapon envelope parameter recognition; energy management; gun tracking; cockpit switchology; basic flight maneuvers; and gunsight control

15 INDEPENDENT VARIABLES:
Practice in an aerial combat engagement simulator

22 SYSTEM/CLASS:
Tactical Air Command Aerial Combat Engagement Simulator

24 NUMBER OF PAGES:
0010

25 NUMBER OF REFERENCES:
0002

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Air Combat Maneuvering Training in a Simulator

37 REPORT AUTHOR:
Meshier, C.W.; Roberts, J.P.

38 REPORT DATE:
75/10/00

Key Number

40 ORIGINATING ACTIVITY:
Vought Corporation, Dallas, Texas, and Tactical Fighter Weapons Center, Nellis Air Force Base, Nevada

52 PUBLISHER/SPONSOR:
Advisory Group for Aerospace Research and Development, North Atlantic Treaty Organization

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 066
10 March 1978

Key Number

1 ACCESSION NUMBER: AD- 858 640

4 CITATION:
Taylor, R.; Gerber, A.; Allen, M.; Brown, L.; Cohen, E.; Dunbar, D.; Flexman, R.; Hewitt, W.; McElwain, D.; Pancoe, E.; Simpson, D. Study to Determine Requirements for Undergraduate Pilot Training Research Simulation System (UPTRSS). Air Force Human Resources Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, AFHRL-TR-68-11, July, 1969.

5 ABSTRACT:
PURPOSE: The purpose of this study was "to demonstrate the maximum effective utilization of simulators in undergraduate pilot training, and to define the future generation simulators" for such training.
SUMMARY: It is not possible to convey in even a lengthy abstract the information contained in the report. It has almost 300 pages of carefully organized, terse delineations of minimum simulator performance requirements. For the time, it was an exhaustive handbook which not only influenced the design of post-1969 flight simulators, but can serve still as a detailed reference for simulator design. Recommended minimum performance standards were developed from analyses of training requirements for airwork and aerobatics, circling approach, takeoff and landing, formation flight, navigation, low-level flight, night flight, and instrument flight. Considering only T-37 and T-38 simulators, required capabilities were discussed for: (a) crew station configuration, including crew facilities, cockpit configuration (extent of simulation, instructor/trainee provisions, location of stations), cockpit motion, visual systems provisions, and expandability and adaptability; (b) complexity of aircraft simulation, including cockpit instrumentation, tolerances for performance and post-stall and spin simulation, flight and engine simulation including jet wake and downwash simulation and performance degradation, general aircraft systems (those for fuel and electrical management and hydraulics, flight control, ejection, cockpit environment control, etc.), and communication and navigation aids; (c) instructor/operator/experimenter stations including modes of operation, research area layout, malfunction insertion; peripheral hard-copy outputs, digital plotting capability, data analysis, intercom facilities--even operator-trainee ratio; (d)

Key Number

computation functions covering single processor, multiprocessor, and multicomputer configurations and their comparisons, processing speed, data word size, instruction repertoire, memory storage, provisions for adaptability and growth, interface equipment, input/output devices, and overall construction; (e) mathematical models, including detailed listings of equations for various subsystems and purposes and integration techniques and computational guides for them, accuracy required, iteration rates, uses of mathematical models in malfunctions, fidelity issues and automated training, and how to optimize computer time and storage; (f) operational, utility, and diagnostic software programs together with programming languages, structure of the executive program, guides for sharing simulation routines, and function and radio aids compilers for use in program modifications. With these foundations, the authors then pursued in considerable detail the major simulation systems for (g) motion, (h) vision, and (i) other environmental effects. As for (g), discussions focused on how conclusions were derived, (subjective) assessment of maneuvers, motion requirements, motion system control loop, desirable motion features, software (drive signal formulations, the combining or integration of visual and motion system capabilities), and synthetic seat-feel simulation (sustained acceleration and necessary devices therefor). Existing equipment and systems were then examined vis-a-vis motion system requirements. As for (h), visual simulation, the approach was described and following discussions focused on requirements for parameters, flight training areas, and the operator-instructor interface; on visual system designs (film projection, transparency reconstruction, electronic image generation); and on direct-viewing and infinity-image displays. Four types of visual systems were recommended, each to serve purposes not practical or possible with the others. As for (i), needs for aural cue simulation were listed with brief comments on each, and a need for introducing smoke into the cockpit was mentioned. The last four sections of the report were devoted to discussions, also detailed, of present and recommended adjunct training capabilities (e.g., performance data analysis, student feedback), training site requirements and facility configurations, maintenance provisions, and a survey of vendors. It should be noted that in all discussions in which it apparently mattered, distinctions were made between requirements for T-37 and T-38 simulation, and advantages of simulation were stressed for teaching recovery from emergencies (e.g., spin in a T-38) that are too hazardous to introduce in the aircraft itself. Also, provisions for fidelity degradation were carefully attended to so as to make possible the use of

Key Number

this "ideal" research simulator in the study of actual needs for various system fidelities.

6 AUTHORS' CONCLUSIONS:
"The ground work (sic) has been laid for the development of an advanced simulation system for use in undergraduate pilot training. The system has been defined, and the technology is capable of meeting the requirements in most of the areas."

7 EVALUATION:
This study reported results of a considerable effort. It also revealed the outcome of a second considerable effort of organization, patience with detail, and terse writing that makes the report a usable as well as a useful reference. Its value as a handbook was stated at the beginning of the abstract and will not be repeated here. Especially valuable for research on simulation training were the provisions for degradation of fidelity, an expensive and perhaps at times unnecessary refinement. Recognition of the need and provisions for system integrations were clearly identified. Questions may be raised as to whether the extent of fidelity envisioned was necessary (or sufficient) in some instances, and subsequent research has provided a number of answers. Nevertheless, the thoroughness with which the authors completed their task gives confidence that, errors of judgment notwithstanding, conscientious extrapolations from training requirements were made in each case, and that no crucial provisions were overlooked. However, a strong bias toward total fidelity is evident. Granted, if the need for fidelity in a particular instance is not known, there should be available a means for determining the need. But cannot some such needs be determined using considerably less expensive subsystems than those described in this report? Furthermore, software requirements for some possibly unnecessary degrees of fidelity can easily over-burden an otherwise adequate hardware system, requiring instead hardware outlays that increase exponentially with the complexity of functions implemented through the software. A prudent approach to simulator design may well be to first determine the need for fidelity, and the degree, and then build the all-encompassing training/research simulator accordingly. In other words, extensive, definitive transfer of training studies using aircraft performance as a criterion should be completed before committing limited financial resources to the construction of systems that have physical fidelity as their only known virtue. And the point holds for relatively inexpensive capabilities such as that required to introduce smoke into a cockpit.

14 DEPENDENT VARIABLES:
Simulator fidelity

Key Number

22 SYSTEM/CLASS:
Advanced flight simulator/training and research

24 NUMBER OF PAGES:
0275

25 NUMBER OF REFERENCES:
0027

28 RESEARCH CLASS:
Logical Study

33 SUPPLEMENTARY NOTES:
Report on development, manufacture, and test of electronic hardware

36 REPORT TITLE:
Study to Determine Requirements for Undergraduate Pilot Training Research Simulation System (UPTRSS)

37 REPORT AUTHOR:
Taylor, R.; Gerber, A.; Allen, M.; Brown, L.; Cohen, E.; Dunbar, D.; Flexman, R.; Hewitt, W.; McElwain, D.; Pancoe, E.; Simpson, D.

38 REPORT DATE:
69/07/00

40 ORIGINATING ACTIVITY:
General Precision Systems, Inc., Link Group, Binghamton, New York

44 CONTRACT/PROJECT/TASK:
F33615-68-C-1604

48 REPORT NUMBER:
AFHRL-TR-68-11

49 OTHER REPORT NUMBER:
LR-104/ECOM-02273-F

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Wright-Patterson Air Force Base, Ohio

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

Key Number

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 067
13 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Gundry, A.J. Thresholds to Roll Motion in a Flight Simulator. JOURNAL OF AIRCRAFT, 14(7), 624-631, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the report was to obtain threshold values for motion stimuli in a flight simulator and to investigate the effects of a concurrent cognitive task on thresholds to angular motion.
METHOD: The 10 Ss consisted of 4 females and 6 males whose simulator and flying experience was generally limited but ranged from none to "extensive". The Redifon 101 simulator was "on the ground" with engines and instruments off and pitch system frozen. Roll motion cues, obtained from a signal from a PDP-12 computer, were equivalent to a 0.25-sec full-scale aileron input to the right or left. The simulator reached peak velocity in 0.25 - 0.3sec, washed out to zero in another 1.7sec, and returned to the upright position in another 5sec. Ss received 40 trials with each of 4 task loadings on each of two consecutive days except for 3 Ss who completed both sets of trials on the same day. After each motion stimulus was presented, the S indicated "left" or "right", depending upon his judgment of the direction of the roll. The four task conditions, approximately counterbalanced across Ss, were: Task 1--no numbers were presented; Task 2--numbers were presented through earphones but Ss were told to ignore them; Task 3--numbers were presented and Ss were asked to repeat them; and Task 4--numbers were presented and Ss were asked to add three to each number and reply.
RESULTS: Threshold angular velocity was significantly lower under Tasks 1 and 2 than under Task 4 (t = 2.58, 2.82, respectively, p .LT. .05). Threshold angular velocity under Task 3 did not differ significantly from that under Tasks 1, 2, and 4. Standard deviations did not differ significantly between tasks. Mean magnitudes of angular velocity thresholds were 0.12deg/sec under Task 1 and 2 conditions and 0.17deg/sec under Task 4. The Task 3 mean was .15.

6 AUTHOR'S CONCLUSIONS:
As the processing demands of the tasks increased, the threshold increased, but the mean standard deviation did not

Key Number

change. "Hence thresholds to motion appear to suffer from attenuation (of all signals on that channel) in the presence of a concurrent task." An "explanation for the present findings of very small threshold values for angular velocity is that subjects were detecting tilt or radial and tangential linear accelerations, due to the fact that they were some distance from an earth-horizontal rotation axis." The results of any motion detection experiment in a simulator were questioned because Ss would always be giving more attention to motion cues than they would in the real situation. "A procedure must be used which does not involve the subject attending to motion cues to an unrepresentative extent . . . there is much to recommend abandoning the sensory threshold to motion as a useful concept for flight simulation, and to use instead values of an effective threshold to motion, which are determined by observing an operator's control behavior."

7 EVALUATION:

It is difficult to evaluate this paper. On the one hand the author did a better than usual job of integrating material from other studies, and much of the value of the paper derived from that integration. However, these discussions seem to have established that the author's experiment was unneeded. For example, the conclusion that "there is much to recommend abandoning the sensory threshold to motion as a useful concept for flight simulation . . ." was not drawn from the experiment but from the literature review. The author's point was that such baseline data as he sought were useless, that any meaningful thresholds to motion--if indeed such exist--must be established during flight task performance. Conclusions such as this not only did not require his data, they point to the necessary futility of his experimental effort. The extensive literature cited could have been examined more critically. In almost all cases only a footnote identified a source that allegedly supported a point developed by the author, with no explanation of what the cited authors found or how they arrived at their results. Some of the cited research is uninterpretable because of methodological and logical flaws. A critical evaluation of these source materials was needed. Furthermore, much of the discussion concerning information processing, as it related to the reported interference of task loading with motion cue detection, had no empirical basis. While multiple tasks produce mutual interference unless they are thoroughly discriminated, the processing channels and mechanisms alluded to are hardly established phenomena. As for the experiment itself, almost no information was provided regarding how thresholds were actually determined. There were also two problems in the analyses of data. First, all Ss participated in all tasks, yielding correlated observations,

Key Number

but there was no reference to use of significance tests appropriate for correlated means and correlated standard deviations. Second, four tasks were involved and the mean of each was compared with that of each of the others using a t test. Probability (significance) values in a t table apply only when two means are drawn from a population. Drawing four considerably increases the likelihood that extreme values will differ sufficiently to show a false-positive result, and it was only for extreme values that significance was reported. What was needed was a repeated measures ANOVA so that all four task means could have been tested for homogeneity simultaneously. With these shortcomings in data analyses, together with only borderline significance in the first place, no reliance can be placed on statements such as "The results clearly indicated that there was a (Task) effect" and "The present experiment has demonstrated that the magnitude of thresholds to motion depend (sic) upon the amount of processing resources available for motion detection."

10 AUTHOR'S RESEARCH SUGGESTIONS:
A procedure should be designed to test motion thresholds in a realistic setting.

14 DEPENDENT VARIABLES:
Threshold for roll motion cues

15 INDEPENDENT VARIABLES:
Magnitude of roll motion cues; cognitive loading task

16 MEASUREMENT/STATISTICAL METHODS:
t test

23 SUBJECT POOL:
Female students and assistants; male trainee pilots, engineers, technicians, and transport pilots

24 NUMBER OF PAGES:
0036

25 NUMBER OF REFERENCES:
0053

28 RESEARCH CLASS:
Experimental Analysis

Key Number

29 RESEARCH METHOD:
Formal experiment/single variable

36 REPORT TITLE:
Thresholds to Roll Motion in a Flight Simulator

37 REPORT AUTHOR:
Gundry, A.J.

38 REPORT DATE:
77/00/00

40 ORIGINATING ACTIVITY:
RAF Institute of Aviation Medicine, Farnborough, United Kingdom

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 068
13 March 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Charles, J.P.; Willard, G.; Healey, G. Instructor Pilot's Role in Simulator Training. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN 75-C-0093-1, March, 1976.

5 ABSTRACT:
PURPOSE: The purpose of the report was to define the role of the Navy Instructor Pilot (IP) in flight training involving simulation and to specify IP training goals in terms that could be used for functional design of candidate consoles.
METHOD: The approach consisted of: (a) a literature review, (b) a survey of intructor functions and training requirements for many types of simulators, (c) an analysis of application and methodology, and (d) a functional specification for improved IP consoles. Three levels of simulator development were considered: (a) existing operational simulators, (b) simulators under procurement, and (c) advanced (optimized) simulators. The data were obtained from several Readiness Training Squadrons (RTS).
RESULTS: In single-place fighter/attack systems, the IP conducted all training from familiarization to tactics and the Simulator Operator (SO) directly assisted him in the operation of the Weapon System Trainer (WST). The SO conducted most of the Cockpit Procedures Training (CPT). In multi-place fighter/attack systems, the IP conducted only the flight portion of the syllabus, with the Naval Flight Officer Instructor (NFOI) conducting the weapon systems training. In anti-submarine warfare fixed wing systems, the IP conducted pilot training alone, with the SO helping in maintenance tasks. The degree of the IP's involvement in simulator operation varied with the system and type of trainer. Generally, the IP and SO were not adequately trained in simulator operation or utilization or in instructional methods. The simulator syllabi were too vague and flight-oriented to exploit simulator capability. Some of the complex instructor consoles exceeded the capability of even specially trained instructors. The role of the fleet IP was not identified because simulator time and syllabi were not available. Operational Flight Trainers (OFT) and WSTs were used extensively as CPTs. In the RTSs, WSTs were not used as such; instead, pilots were trained using the OFT mode and the crew by the tactics mode. However, fleet squadrons used the WSTs in the integrated mode to conduct full mission training.

Key Number

6 AUTHOR'S CONCLUSIONS:
The interaction of the IP, NFOI, and SO must be defined before the role of the IP can be identified. Then a modular approach to IP console design would be feasible. A simulator utilization program should be established for IPs and SOs. IPs should receive training on "how to instruct." Syllabi directed to efficient and effective use of simulator training should be developed. Instructor console design objectives should be used that reflect training or instruction functions instead of simulator control. The utilization of CPT/Cockpit Orientation Trainers should be increased to free OFTs and WSTs for system training. "(S)imulator training is not well employed, standardized, or in general appreciated by IPs."

7 EVALUATION:
This lengthy report provides ample descriptive data on various training systems. However, the goal of defining the IP's role in training was never really attained, and hence little definitely could be said regarding necessary and sufficient IP console design. It is evident that the authors expect to relate console design to training functions of IPs in contrast to simple simulator control. A subsequent report (see Cross-References) examines IP training roles in detail.

10 AUTHOR'S RESEARCH SUGGESTIONS:
A study of the NFOI's role in simulation should be undertaken.

12 CROSS-REFERENCES:
Charles, J.P. Instructor Pilot's Role in Simulator Training (Phase 2). Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN 76-C-0034-1, August, 1977.

22 SYSTEM/CLASS:
Instructor pilot consoles

24 NUMBER OF PAGES:
0098

25 NUMBER OF REFERENCES:
0018

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Survey/descriptive

36 REPORT TITLE:
Instructor Pilot's Role in Simulator Training

Key Number	
37	REPORT AUTHOR: Charles, J.P.; Willard, G.; Healey, G.
38	REPORT DATE: 76/03/00
40	ORIGINATING ACTIVITY: Appli-mation, Inc., San Diego, California
44	CONTRACT/PROJECT/TASK: N61339-75-C-0093/Task 5751-01P01
48	REPORT NUMBER: NAVTRAEQUIPCEN 75-C-0093-1
49	OTHER REPORT NUMBER: AISR/375
52	PUBLISHER/SPONSOR: Naval Training Equipment Center, Orlando, Florida
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 069
23 November 1979

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Chalk, C.R.; Wasserman, R. An Assessment of the Role of Simulators in Military Tactical Flight Training, Volume 1: Assessment Based on Survey Interviews. Calspan Corporation, Buffalo, New York, AK-5970-F-1 (Volume 1). 30 September, 1976.

5 ABSTRACT:
PURPOSE: This study was to provide the Office of Assistant Secretary of Defense (Office of the Director of Planning and Evaluation) with an assessment of the status of simulators and their potential roles in military tactical flight training.

SUMMARY: Forty-six military and industrial organizations were visited to conduct interviews. Thirty-five simulators were examined, 13 of which were flown by Calspan engineering pilots. Findings were as follows. (a) Inexpensive cockpit procedures trainers are highly effective. (b) Current instrument flight trainers were excellent for cockpit, radio operation, fuel management, navigation, and instrument flight procedures. Users generally preferred motion systems with these devices. (c) Many failure states have been designed into emergency procedures trainers, but only a few have been used in training. The number of malfunctions included in the design should be consistent with training requirements and schedule constraints. (d) Devices with visual displays were being used for takeoff and landing practice, on ground and on carriers, but lateral control anomalies and discrepancies in sink rate should be corrected. Greater fidelity of math models and data bases is needed when visual displays are used. (e) Fixed-base simulators have been used successfully for training formation flight, but transport delays must be minimized and a large field of view (FOV) is necessary. Prototype visual equipment was not quite adequate for judging range and range rate. (f) No information was available regarding air-to-air refueling training, but it should be feasible because it requires a less extensive display than formation flight. (g) Simulators may be the only feasible way to train how to cope with dynamic failures. However, data describing the aircraft, display, and control effects of the failures may be hard to obtain. (h) Simulators should be used to teach limits of maneuvers so that crews can perform up to the limits with confidence. (i) "The motion and force environment encountered

Key Number

in uncontrolled flight cannot be duplicated in ground simulators but . . . simulation . . . to the extent possible is important to create the stress and confusion associated with out of control flight." (j) Some claimed that nonpilot crew members of the S-3 and E-2B could be trained entirely in a simulator, but lack of environmental realism should be corrected by interspersing device and aircraft training. (k) Feasibility studies had demonstrated that simulators can be used to supplement ground attack training. However, improvements were needed in visual system FOV, scene detail and resolution, image brightness and color, and size of gaming area. Desirable capabilities included moving ground targets, defensive fire, weapon impact and target damage, simultaneous displays of ground detail and airborne aircraft, easy change of scene or detail, and simulation of weapon system sensors. (l) It has been demonstrated that air combat missions could be trained in devices but deficiencies existed: image quality and resolution often inadequate for target aspect determination; rear view too restricted; poor dynamic fidelity at high angle of attack; control imprecision due to time delays; poor altitude and load factor cues; target too easy to acquire due to brightness contrasts; and restriction of display to only one aircraft. (m) Commercial airline and Air Force programs have cross-country instrument flight in common, but airline training practices may not be applicable to combat training, especially when Air Force pilots are generally less experienced. (n) ISD should facilitate effective full mission and/or part task simulator training, but it cannot be assumed that all tasks can be trained in a full mission device. (o) Tactical training officers believed that reductions in aircraft time had already had undesirable effects, so additional device training should supplement, no substitute for, flight time. Problems related to nine areas were also discussed: fidelity; motion and force cueing; time delays and lags; visual image generation and display; radar simulation; FLIR and LLTV simulation; certification, modification, revalidation; software management; and transfer of training.

7 EVALUATION:

This appeared to be a thorough study of the status of simulator capabilities and user beliefs regarding requirements for simulator training. No attempts were made to validate the beliefs, however. For example, the discussion of transfer of training was very general in nature and less than 2 pages long. Volume 2, which is devoted to a survey of literature, may address the validation problem more fully.

22 SYSTEM/CLASS:

Flight simulators

Key Number

24 NUMBER OF PAGES:
0150

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

32 DESCRIPTIVE NOTES:
Final: 15 April 1976 - 30 September 1976

36 REPORT TITLE:
An Assessment of the Role of Simulators in Military Tactical Flight Training, Volume 1: Assessment Based on Survey Interviews

37 REPORT AUTHOR:
Chalk, C.R.; Wasserman, R.

38 REPORT DATE:
76/09/30

40 ORIGINATING ACTIVITY:
Calspan Corporation, Buffalo, New York

44 CONTRACT/PROJECT/TASK:
MDA903-76-C-0274

49 OTHER REPORT NUMBER:
AK-5970-F-1 (Volume 1)

52 PUBLISHER/SPONSOR:
Calspan Corporation, Buffalo, New York

56 TYPE OF PUBLICATION:
Technical report

64 LOCATION SYMBOL:

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069-4

ABSTRACT 070
19 November 1979

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Edwards, W.; Guttentag, M.; Snapper, K. A Decision-Theoretic Approach to Evaluation Research. In E. Struening and M. Guttentag (Eds.), HANDBOOK OF EVALUATION RESEARCH. Beverly Hills, California: Sage Publications, 1975. Pp. 139-181.

5 ABSTRACT:
PURPOSE: This article examined problems in approaches to evaluation research and presented a model to overcome the problems.
SUMMARY: Major problems in evaluation were classified under five "folkways." (a) A program becomes reified in that it is conceived as "a fixed, unchangeable object, observable at various times and places." As a result, attempts to isolate individual variables necessarily fail because programs differ from place to place, and from time to time. This variability does not permit the isolation of effects of individual variables. (b) An insistence on causal inferences leads to "why" questions when "what" should be the information sought. Consequently, models are constructed that cannot hope to capture the complexities of program variations. (c) Evaluative pseudo experiments become "Procrustian beds" into which programs are forced. The problem is with graduate school training to seek causation, which supposedly can be found only in experiments designed for statistical inferences. (d) Rigid evaluation designs are used that do not recognize: changes during the program in values of persons served and of those responsible for the program; the evolving "shape" and "character" of the program; changes in societal circumstances; and evolving insights as program events and consequences accumulate. (e) Evaluative information is conceived as a massive compilation of detailed data, but most data are of tangential significance at best. Any evaluation methodology should link inferences about states of the program with values of decision makers, producing decisions accordingly. Four phases are involved. First, the decision problem must be recognized--its nature, dimensions, and raw materials needed for decision. Second, contingencies must be identified by probabilistic statements. Third, outcomes must be evaluated, not as probabilities but as "explicit, numerical answers" to questions of "how

Key Number

good" or "how bad?" Fourth, choices must be made among alternatives. Ten steps of multi-attribute utility analysis lead to the outcome evaluations in Phase 3. (a) Identify person or organization for whom utilities are to be evaluated. (b) Identify decisions relevant to the utilities. (c) Identify factors (entities) to be evaluated. (d) Determine relevant value dimensions. (e) Establish ranks for dimensions based on their importance. (f) Assign ratio ratings to ranked dimensions. (g) Compute importance weights. (h) Locate the measure of each factor or entity on each dimension. (i) Compute entity utilities. (j) Make decisions. As conceived and illustrated, this process is seen as quite flexible.

7 EVALUATION:

It cannot be determined from this article just how the steps in evaluating outcomes are completed. The impression is that it is a fairly mechanical, though tedious, process. Especially missing is assurance that the procedure is not simplistic, and that it is systematic and rigorous enough for different evaluators of a program to arrive at comparable results. Emphasis during Phase 2 is on Bayesian subjective probabilities, which can vary notoriously. The argument seems to have been that a choice must be made between the rigid experimentation taught in graduate schools and a method with little if any rigor. Research courses in colleges of education (educational programs were the primary concern of this article) do tend to over simplify research methodologies. However, research education in other disciplines (sociology, social psychology, management science, economics) is not so restrictive, so the straw man of education is not the only "rigorous" alternative. In brief, this article lacks depth. It is also very disconcerting to see "casual" used numerous times in the text, when with one exception "casual" surely was intended. There are also a host of confusing statements such as "pseudo-experiments should be avoided if possible. . . (yet) In some cases they may well be worth doing."

24 NUMBER OF PAGES:

0043

25 NUMBER OF REFERENCES:

0028

28 RESEARCH CLASS:

Logical Study

29 RESEARCH METHOD:

Organization

Key Number

36 REPORT TITLE:
A Decision-Theoretic Approach to Evaluation Research

37 REPORT AUTHOR:
Edwards, W.; Guttentag, M.; Snapper, K.

38 REPORT DATE:
75/00/00

40 ORIGINATING ACTIVITY:
University of Southern California, Los Angeles, California;
George Washington University, Washington, D.C.

52 PUBLISHER/SPONSOR:
Sage Publications, Beverly Hills, California

56 TYPE OF PUBLICATION:
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64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 071
2 April 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Bakey, G.A.; Karplus, W.J. Computers for Real Time Flight Simulation: A Market Survey. Computer Science Corporaton, Mountain View, California, NASA CR-2885, July, 1977.

5 ABSTRACT:

PURPOSE: The purpose of this study was to conduct an extensive computer market survey to identify those peripheral computer systems that would be most suitable for current and future flight simulation studies at the NASA/Ames Research Center.

METHOD: Two types of "benchmarks" were used in selecting and evaluating candidate computer systems. First, a mathematical model that defined certain required computer capabilities was developed. The Rotor Systems Research Aircraft (RSRA), operating in the helicopter mode, was selected as a second benchmark because its demands on computer performance were equivalent to those anticipated at NASA/Ames. In developing an information/data base, "numerous" conferences were held with knowledgeable individuals in 13 or more organizations (universities, industries, etc.) and 14 vendors of computers were visited to examine systems and determine their capabilities. Only hardware costing from 100K-750K was considered.

RESULTS: Five candidate hardware systems were identified and examined in some detail. The AP-120B (Floating Point Systems, Inc.) had adequate hardware design, operational characteristics, and speed. Of the five candidates, it had "by far the most impressive software support." However, the AP-120B was not developed for simulation purposes, and it cannot be assumed that because it was adequate for benchmark problems that it can accommodate other aerospace problems as well. Specifically, its memory may not be sufficient for signal processing applications. Another disadvantage is that all data must enter and leave the unit via an interface module and a host computer. However, a mean time of 3800 hours between hardware failures was reported, and with an expanded program source memory and a reassembly extensive memory table, an AP-120B would cost only 80K. The AD-10 (Applied Dynamics, Inc.) could also be usable if it came supplied with an integrated module. It too had adequate hardware design, operational characteristics, and speed. Existing software support was meager, however, although the manufacturer was expected to

Key Number

overcome this difficulty. A distinct advantage of the AD-10 was that the manufacturer's staff "are among the leading experts in the mathematical modeling and simulation of aerospace systems." The greatest shortcoming of the AD-10 is that it is a fixed-point computer. Also, data word size may prove to be too limited. Initially, "the mean time between hardware failures . . . would not be exceptionally attractive . . . (but) a realiable and satisfactory product will ultimately result." An adequately expanded AD-10 would cost approximately 85K, but preparation of necessary software packages would increase the price. The heterogeneous element processor (HEP) being developed by Denelcor, Inc., would be adequate by all criteria (except possibly for a cost in excess of 750K) if the system fulfills specifications and if appropriate software is designed. The G-471 (W.W. Gaertner Research, Inc.) has adequate hardware, operational characteristics, and speed, but no software existed for it at the time of this study. The manufacturer proposed to provide a fully designed and implemented assembler to aid in programming, but the G-471 was designed for signal processing applications and the vendor probably could not help with simulation applications. Given adequate software, the G-471 as conceived would meet all NASA simulation requirements. However, the system was not in operation so reliability data were lacking. Depending upon capacity desired, the G-471 would cost between 50K and 200K. The fifth and last candidate was the special purpose helicopter simulator, or the SPURS (Paragon Pacific, Inc.). It was a hybrid computer that used entirely integrated circuits. It was adequate for NASA purposes by all criteria used in this study, although it lacked flexibility due to its hardwiring. Reliability data were not then available. The cost of a SPURS system would be approximately 120K.

6 AUTHOR'S CONCLUSIONS:

The authors concluded that: (a) "a host computer of moderate size supported by a peripheral processor is capable of meeting the simulation requirements"; (b) "with the exception of the AP-120B, all (peripheral processors) are so fast that the time required . . . will be substantially overshadowed by the time required by the host computer for data transfers, communications, etc."; (c) the Digital Equipment Corporation PDP-11/70 may be adequate as a host computer; (d) "with the exception of the HEP, all of the peripheral processors constitute relatively moderate additions to the overall cost of the integrated system,"; (e) as of February 1977, the AP-120B was the only processor ready as an off-the-shelf item--the others ranged from nearly complete to still on the drawing board; (f) minimum software for all systems would include an assembler, a

Key Number

simulator, a subroutine library, and diagnostic packages (only the AP-120B had a simulator available); and (g) all analog and hybrid computing devices should be eliminated from further consideration, except that SPURS may be a good back-up system.

7 EVALUATION:
This is a good report both from the standpoint of content and of presentation. Grounds (benchmarks) for evaluation were developed well, and their applications were systematic. Except as suggested by a listing in the Appendix of vendors consulted, no information was provided as to which or how many systems were examined and eliminated from consideration. An additional omission, clearly recognized by the authors, was the lack of a full range of required computer characteristics in benchmark criteria. Computational criteria focused primarily on the speed of solution of differential equations--admittedly the most demanding task to be performed by a peripheral system--with the host of other computational requirements largely ignored. Nevertheless, the effort covered some important hardware requirements and examined alternative systems according to clearly relevant criteria.

10 AUTHOR'S RESEARCH SUGGESTIONS:
(a) "A detailed and systematic study should be undertaken to prepare the specifications for the host computer and the communication links to the cockpit stations." Also needed are studies of (b) the applicability of the AP-120B with reference to adequacy of memory, interfacing problems, and programming difficulties; (c) the applicability of the AD-10, emphasizing the implementation of the integration module and software packages; and (d) alternative candidates for a peripheral digital processor.

22 SYSTEM/CLASS:
Flight simulators/peripheral processing systems

24 NUMBER OF PAGES:
0082

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Survey/evaluative

Key Number

36 REPORT TITLE:
Computers for Real Time Flight Simulation: A Market Survey

37 REPORT AUTHOR:
Bakey, G.A.; Karplus, W.J.

38 REPORT DATE:
77/07/00

40 ORIGINATING ACTIVITY:
Computer Sciences Corporation, Mountain View, California

44 CONTRACT/PROJECT/TASK:
NAS 2-7806

48 REPORT NUMBER:
NASA CR-2885

52 PUBLISHER/SPONSOR:
National Aeronautics and Space Administration, Washington, D.C.

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65 LOCATION FILE:

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ABSTRACT 072
2 April 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Forster, J.D. Sensitivity of Army Helicopter Operating and Support Costs to Changes in Design and Logistic Parameters. Logistics Management Institute, Washington, D.C., LMI Task 75-14, May, 1977.

5 ABSTRACT:
PURPOSE: The purpose of this study was to develop operating and support (OS) costs review procedures, to identify methodologies that are useful in assessing the cost effectiveness of new weapons systems, and to analyze weapon systems acquisition to reduce costs.
SUMMARY: Sources for data regarding Army helicopter costs include literature published by helicopter manufacturers and research firms, Aviation Systems Command (AVSCOM) literature, systematic field reports, and official Army publications. For these data to be used efficiently, they must be evaluated and integrated into a system of basic data elements. Such an effort was difficult because long-term trend analyses for separate weapon systems were lacking. The Army had proposed a RAM-LOG system (Realiability Availability Maintainability/Logistics) designed for recording data during tests. RAM/LOG was expensive, and its implementation had not been decided, but it could be a source of long-term trend information regarding reliability and maintainability. A shortcoming of RAM/LOG was that it addressed manufacturer's performances to specifications and not "nonproductive" direct and indirect manpower costs. Army publication AR 570-2 did provide for manpower costs, however. Also, various unit level documents provided details of rank, specializations, number of men assigned, etc., for various weapon systems. Together with manpower, replenishment spares (to replace condemned components, but costs include overhaul) and initial spares (maintenance items) comprised the "primary" cost of helicopter OS. Other costs derived from material, labor, and transportation for "high time" overhauls as well as from modifications and ammunition usage. Results of a boundary analysis were reported (but not the analysis itself); however, no clear bases for intepreting them were provided.

Key Number

6 AUTHOR'S CONCLUSIONS:
(a) RAM/LOG records should not be a sole source of manpower estimates for a costing program because they exclude indirect time; (b) summaries of long-term reliability and maintainability trends should be included in Army data sources; (c) the Army should resolve inconsistencies in definitions of "lower level" manpower costs; (d) a careful study of optimum indirect manpower levels might lead to a reduction in manpower costs; (e) levels of mean times between dynamic component removal should conform to funding for reliability achievement; (f) the Army should develop a resource allocation model for optimizing the purchase of initial and replenishment spares; and (g) weapon system cost estimates should include extreme values of OS costs.

7 EVALUATION:
The principal value of this report was the identification of shortcomings and needs in data resources. However, the manner of presentation made it difficult to follow the author's arguments in detail.

14 DEPENDENT VARIABLES:
Helicopter operation and support costs

22 SYSTEM/CLASS:
Helicopters

24 NUMBER OF PAGES:
0054

25 NUMBER OF REFERENCES:
0029

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Critique

36 REPORT TITLE:
Sensitivity of Army Helicopter Operating and Support Costs to Changes in Design and Logistic Parameters

37 REPORT AUTHOR:
Forster, J.D.

38 REPORT DATE:
77/05/00

Key Number	
40	ORIGINATING ACTIVITY: Logistics Management Institute, Washington, D.C.
44	CONTRACT/PROJECT/TASK: DoD No. SD-321 (75-1/4)
49	OTHER REPORT NUMBER: LMI Task 75-1/4
52	PUBLISHER/SPONSOR: Logistics Management Institute, Washington, D.C.
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 073
3 April 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
La Rochelle, D.F. A Cost Effectiveness Analysis of an Air Combat Simulator. Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, GSA/SM/73-10, June, 1973.

5 ABSTRACT:
PURPOSE: The purpose of this study was to prepare a cost effectiveness analysis of a simulator for air-to-air combat (SAAC) training.
SUMMARY: Cost effectiveness must consider training effectiveness, and for a simulator this implies that training occurring in a simulator should transfer to performance in an actual aircraft. Futhermore, the utilization of transfer data in cost analyses requires a meaningful index or measure of transfer, or so it would seem. No suitable index was found in a search of literature regarding transfer, so an alternative stimulus-response (S-R) approach to determining transfer, based of Osgood's transfer surface, was selected for the present analysis. This technique would entail an S-R analysis of combat maneuvers/techniques as performed in actual aircraft and in the SAAC. One maneuver, the high speed yo-yo attack, was chosen for S-R analysis. The maneuver was described and 21 stimuli were identified as characteristic of response cues. Because these stimuli could be represented in the SAAC, and because pilot responses to them in the SAAC were similar to those in aircraft, it was concluded that possible transfer from SAAC to aircraft would probably occur. As a further basis for a cost-effectiveness analysis, the number of times attacks could be practiced within a 48-minute training mission, and the numbers of minutes actually devoted to attack practice, were determined for aircraft and SAAC. The cost analysis itself compared the F-15 air combat trainer program to that program with varying amounts of utilization of the SAAC with the F-15. Costs for the F-15 alone included those incurred by combat area training units, and those incurred by continuation training in operational units, plus attrition costs attributable to additional flying time. For the SAAC/F-15 program, procurement, operating, and maintenance costs were added. The issue then became the overall costs for given amounts of combat practice in the F-15 and in the SAAC. A comprehensive equation was developed for F-15 which included costs for fuel consumption, flyaway and peculiar support/

Key Number

aircraft, depot maintenance, officer replacement, undergraduate pilot training, and combat crew training. Multipliers in the equation provided for rates of aircraft accidents and pilot fatalities, and for total usage. The SAAC equation included costs for prototype and additional equipment and maintenance. In determining overall training costs, multipliers were used representing the proportion of SAAC use and assumed varying proportions of positive transfer from SAAC to F-15. The results revealed that the cost effectiveness analyses were relatively insensitive to varying amounts of transfer. Because operating costs for the SAAC were low, even small amounts (but not zero) of transfer per SAAC session could be compensated economically by simply increasing the number of SAAC training sessions.

7 EVALUATION:

This well written report provides a useful example of rational techniques in cost analysis. The lack of an adequate index of transfer was overcome through an approach that incorporated transfer as an unknown, albeit positive, quantity. It was thus possible to identify the relative role of SAAC training effectiveness compared to effects of other cost factors. The overall cost equations appear reasonable. Arguments supporting particular expressions in the equations were not given, however, and it is likely that some would disagree with particular formulations. The principal shortcoming though, is the unqualified inference by the author that small amounts of transfer can be compensated by additional SAAC sessions. The inference was based on an unjustified use of the transfer multiplier in comparison of F-15 and SAAC costs. Specifically, a single quantity (proportion) was used to equate SAAC hours and F-15 hours. For example, if transfer is 50 per cent as in an example given by the author, then two SAAC hours equal one F-15 hour. But such a statement can hold only for a given number of SAAC sessions. The first two hours of SAAC practice may equal one hour of F-15 practice, but if so it does not follow that 20 hours in SAAC equals 10 hours in F-15. Such extrapolations must eventually yield transfer exceeding 100 percent! Both logic and empirical data show transfer to be a decreasing, asymptotic function of practice. The actual function varies with conditions, but the monomolecular equation from chemistry, used by learning theorists since at least 1910, illustrates a simple formulation. Stated as a differential equation, the amount of transfer on the nth trial equals a constant times the quantity, (maximum possible transfer minus the amount of transfer achieved during the first n minus 1 trials). Hence, if transfer is 50 per cent for 2 hours in SACC, and maximum possible transfer is 70 per cent, 4 hours in SAAC would yield 60 per cent transfer, 6 hours,

Key Number

65 per cent, etc. Thus at some point, practice in SAAC must yield diminishing returns. Incorporating this point in the equations would have complicated the analysis, but it also would have made extrapolations more reasonable in that guides could have been established for identifying limits for cost-effective use of the SAAC.

18 SPECIAL ANALYTIC TECHNIQUES:
Stimulus-response analysis

22 SYSTEM/CLASS:
Flight simulators/air-to-air combat (SAAC)

24 NUMBER OF PAGES:
0084

25 NUMBER OF REFERENCES:
0046

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Deductive reasoning

32 DESCRIPTIVE NOTES:
Air Force Institute of Technology thesis

36 REPORT TITLE:
A Cost Effectiveness Analysis of an Air Combat Simulator

37 REPORT AUTHOR:
La Rochelle, D.F.

38 REPORT DATE:
73/06/00

40 ORIGINATING ACTIVITY:
Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio

48 REPORT NUMBER:
GSA/SM/73-10

52 PUBLISHER/SPONSOR:
Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio

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60 DISTRIBUTION STATEMENT:
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64 LOCATION SYMBOL:

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ABSTRACT 074
13 April 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Rivers, H.A. Simulator Comparative Evaluation. USAF Tactical Air Warfare Center, Eglin Air Force Base, Florida, November, 1977.

5 ABSTRACT:
PURPOSE: The purpose of this report was to subjectively evaluate and compare subjectively the capabilities of training devices and make recommendations for features to be included in future tactical fighter simulators.
SUMMARY: USAF Tactical Air Warfare Center (TAWC), Tactical Air Command (TAC), and Aeronautical Systems Division (ASD) chose devices as below for this evaluation. The fighter-configured devices chosen were: F-14; TA-4J; Tornado, Jaguar; simulator for air-to-air combat (SAAC); large-amplitude multimode aerospace research simulator (LAMARS); large-amplitude system/wide-angle visual simulator (LAS/WAVS); large-amplitude motion base simulator (LAMBS); Vought air combat simulator (VACS); motion base simulator (MBS); manned air combat simulator (MACS) 1/2; MACS 3; advanced simulator for pilot training (ASPT); differential maneuvering simulator (DMS); F-4 Redifon; and Buccaneer. The nonfighter configured devices were: Boeing 707 Compuscene Visual; Redifon 707; Redifon DC-10; American Airlines 727 Novoview Visual; American Airlines DC-10; American Airlines DC-10 Redifon Visual; United 737 Novoview Visual; TWA 707 Vital 3 Visual; Flying Tiger DC-8 Vital 2 Visual; FSI DC-10 Vital 2 Visual; Southern Airlines DC-9 night visual system (NVS); Braniff 727 Duoview; Braniff DC-8 Novoview; Continental Airlines Novoview 2; NASA/Ames Redifon Visual; C-135 Singer NVS; USN SH [illegible] LAMPS; S-61 Helicopter; USN S-3A Vital 3; and USN P-3C Duoview. Systems in development were: T-37/38 instructional flight simulator IFS; Link NVS; and calligraphic digital image generation (CDIG or DIGS). Twenty-four representative air-to-air (A/A) tasks were selected for evaluation missions, including transition and formation tasks, basic fighter maneuvers (BFM), and advanced air combat maneuvers (ACM). Twenty-eight air-to-surface (A/S) tasks were selected which included transition maneuvers and progressively more difficult ground attack tasks. All missions were designed to be accomplished in one hour or less. Four fighter-configured and one nonfighter-configured missions were flown by each evaluation pilot. Questionnaires were used

Key Number

to record the pilots' subjective evaluations of simulator capabilities with respect to task accomplishment, training value and risk, physiological effects, and specific features such as visual and motion systems, g suit, g seat, sound cues, etc. Each evaluation team consisted of a project officer, three TAC fighter pilots (as evaluators), a briefing officer, an operations analyst, and a simulator technician. Evaluations of motion simulation were as follows: (a) the overall sensation of motion by beam or platform systems was more realistic and effective in the SAAC than in any of the other A/A simulators; (b) LAMARS, SAAC, and Jaguar were the best systems; (c) platform base effects were influenced by the quality of the visual system; (d) motion bases that provided close correspondence of control inputs, visual scene, and instruments aided instrument flying, takeoff, stalls, and landings; (e) except for motion systems and tasks in (d), motion cues were ignored or assessed as having no effect or being detrimental; (f) motion platforms that provided unrealistic cues were worse than no platform at all; (g) pilots disagreed as to future training value of motion systems; and (h) some of the most satisfactory nonfighter device motion systems were Rediton DC-10, the NASA S-61, and the American 727. The most effective g suit and g seat systems were in the SAAC, and the DMS buffet cues were superior. Evaluations of visual systems were as follows: (a) the ASPT sky/horizon/earth scene provided the best cues for and most aid in performance of transition maneuvers; (b) the ASPT also provided an effective out-of-cockpit environment for A/S events, and its FOV was best; (c) computer generated images (CGI) were more flexible than model board systems; (d) one-window display systems permitted accomplishment only of straight-ahead tasks, and three-window systems were not better except during maneuvering with an object or target in sight; (e) limited FOVs constrain training capabilities for takeoff, approach, and landing; (f) resolution was excellent for all CGI systems evaluated; (g) Redifon DC-10, Braniff DC-8, Continental 727, and NASA S-61 and 737 provided excellent image positioning; (h) color was beneficial for identifying objects and providing realism; (i) scene content was satisfactory in CGI and in model board systems that presented 6,000 or more light points; (j) all model board systems were inadequate in gaming area size, and CGI systems that were satisfactory were in the Redifon DC-10 and Braniff DC-8; and (k) the DMS provided the best target image (TI) features. Air combat maneuver (ACM) realism was "enhanced" by synthetic terrain generation, and the realism of SAAC was generally better than that of the ACM environment of the DMS dome. The MACS 3 TI was adequate for judging aspect and range up to 6,000 - 8,000 feet, but target detail was inferior to that of the DMS and

Key Number

SAAC. MACS 3 target positioning errors were distracting. TI in the MACS 1/2 was brightest and most distinct, at least when it was in the virtual image area, but it did not permit realistic aspect and range judgments at more than 6,000 feet. Target image was limited in the VACS. The LAS/WAVS was adequate for aspect and range estimates within 10,000 feet, but target movement was not satisfactory. The ASPT TI was unsatisfactory because of poor detail, as was that in the LAMARS. The DMS flight performance characteristics were the most accurate, and the SAAC and TA-4J flight performance characteristics were the best overall. The ASPT provided the best special features, but the TA-4J's special features were "notable." The MACS two-versus-one capability, dissimilar aircraft capability, and visual missile trace were the best for A/A training. Airline training devices provided the best simulation of ceiling and visibility conditions. None of the simulators allowed satisfactory instructor observation or control of sorties. The ASPT console design was superior to that of the others, but it was still lacking in some respects.

6 AUTHOR'S CONCLUSIONS:

Conclusions were as follows: (a) acceleration, deceleration, zero-g, sust ·.ed-g, buffet, and on runway cues along with g suit, g seat, and visual scenes provide all the motion necessary for fighter simulation; (b) the platform and beam motion systems were detrimental to A/A training and most A/S tasks; (c) g seat and g suit systems did not provide totally adequate cues; (d) an effective visual scene provided most of the useful motion cues; (e) a realistic gray-out/blackout condition was an effective cue for sustained high-g loading; (f) normal procedures and techniques could be performed only in simulators that duplicated aircraft FOVs; (g) poor clarity, resolution, and detail of the target image did not permit realistic performance of ACM; (h) the sun image as a visual reference point is an important tactical feature; (i) realistic target performance, size, and display are necessary for adequate A/A training; (j) portrayals of threatening aircraft provided realistic air combat training; (k) area of interest presentations in A/S devices were too small and restrictive; (l) lack of detail in visual scene forced pilots to rely unnaturally on cockpit cues to determine flight parameters; (m) only CGI systems afforded the clarity and resolution necessary to recognize and identify objects at normal slant ranges; (n) color proved to be a important factor for normal object recognition and identification; (o) excessive contract on CRT/optical mosaic displays permitted unrealistically easy detection of obj .s; (p) small gaming areas increased task diffic ty by ca sing pilots to spend too much effort trying to remain within the environment; (q)

Key Number

simulator handling and flight performance characteristics that were different from those of the aircraft detracted from overall creditability, increased task difficulty, and could result in negative training; (r) the interactive 2-versus-1 capability is the most important feature for A/A training; (s) cockpit weapon panels, switches, gunsights, or HUDs that were not identifical to those of the aircraft, detracted from overall creditability and degraded training potential; (t) inaccurate simulation of weapon firing envelopes and kill probability detracted from overall creditability and training potential; (u) the ability to defend oneself realistically against a missile fired within parameters enhanced counteroffensive training; (v) a functional radar and accurate simulation of the integration of the complete weapon system contribute to the effectiveness of A/A simulators; (w) sound provided important cues that enhanced performance; (x) moving targets added an important dimension to A/S training; (y) accurate visual depiction of weapon impact added to training; (z) Iron Pilot targets were either too easy or too difficult to defeat; (aa) console operated targets were not effectively controlled; (bb) no consoles were optimized for monitoring task performance; (cc) required instructional features include a pilot's view repeater display; three-dimensional engagement event display; accurate weapon scoring and release parameters; ability to vary ceiling visibility, and runway conditions; voice and video record and off-line playback capabilities; and task record/playback capabilities. Finally, (dd) noticeable pilot fatique resulted after 30-45 minute A/A simulator training sorties.

7 EVALUATION:

This report covers simulator capabilities exhaustively, and it is an especially valuable state-of-the-art description of simulation in 1977. It identified adequate and inadequate simulator features as perceived by the evaluation team, and in most cases explained the bases for judgments. Hence, with due precaution regarding the difference between training and fidelity requirements, it is a useful reference for many aspects of simulator design. The principal shortcoming is that the data on which the reported findings were based were not presented. Surely some subjective evaluations conflicted with others, and it would help in interpreting the findings if such uncertainties had been identified.

22 SYSTEM/CLASS:

Flight simulators

24 NUMBER OF PAGES:

0208

Key Number

25 NUMBER OF REFERENCES:
0000

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Simulator Comparative Evaluation

37 REPORT AUTHOR:
Rivers, H.A.

38 REPORT DATE:
77/11/00

40 ORIGINATING ACTIVITY:
USAF Tactical Air Warfare Center, Eglin Air Force Base, Florida

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Tactical Air Command, Langley Air Force Base, Virginia

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66 LAST DATE OF UPDATE:

ABSTRACT 075
15 July 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Goldstein, I.L. The Pursuit of Validity in the Evaluation of Training Programs. HUMAN FACTORS, 20(2), 131-144, 1978.

5 ABSTRACT:
PURPOSE: The purpose of the article was to conceptualize training program evaluation within a generalization framework. SUMMARY: Four levels or "stages" of validity (generalizability) were discussed in terms of assessment and evaluation components required for each. Stage 1, training validity, concerned the generalization of course objective achievement from one training group to another within the same training environment. Need assessments should focus on behavioral objectives to be attained during the course, as they can be realistically defined in relation to characteristics of the trainee population. Evaluation should focus on achievements of these objectives, and they should be conducted using a rigorous experimental design. Stage 2, performance validity, concerned the positive transfer of training to on-the-job performance. Need assessments should focus on job performance requirements as determined by job/tasks analyses, and these analyses should be conceived within the framework of organizational goals, resources, and constraints. Especially important is the identification of inherent conflicts in organizational goals and practices so that behavioral goals will not be sought during training that will be unacceptable in the job environment. Evaluations involved in establishing Stage 2 validity should be extensions of those in Stage 1 to a rigorous determination of what job performance components were affected by training as well as how and why. Stage 3, intra-organizational validity, concerned the generalization of Stage 1 and Stage 2 validity to successive groups of trainees within the same organization. Need assessments should focus upon the degree of similarity/dissimilarity of objectives for Stages 1 and 2 from one time to another. If job tasks have changed, or their frequency, importance, or difficulty, Stage 3 generalizations can be hazardous. Also, it must be determined that the original training program has not undergone significant change. Thus, evaluations at Stage 3 should be similar to those in Stages 1 and 2, but repeated periodically to ensure that training effectiveness is not being reduced. Stage 4, inter-organizational validity, concerned the generalization of

Key Number

Stages 1, 2, and 3 validities from one organization to another. Because of the large number of differences between organizations, Stage 4 generalizations cannot be made safely, but adaptation of an established training program to new organizational conditions can permit utilization of previously validated training procedures; and repetitions of Stage 1, 2 and 3 evaluations in the new context would protect against unwarranted generalizations.

7 EVALUATION:

Probably most training program evaluators are aware of the problems of generalization of research findings discussed in this report. However, as the author noted, research directed toward systematic attempts to establish Stage 3 and Stage 4 validity is rare. Even Stage 2 (transfer) evaluations are not common, and more often than not, such studies as have been conducted were not designed to determine how and why transfer occurred, or whether goals achieved in training conflicted with real-world working conditions. The value of this report lies in its clear presentation of the generalization issues, and its analysis of course planning and evaluation requirements. Though written with a general orientation, the points are highly relevant to evaluating simulator training, an effort which often ends when the original, controlled, offering of a course is evaluated. Course changes occur, often suddenly, for reasons ranging from instructor preferences to training site philosophies. This article provides a practical framework, albeit one requiring effort, for monitoring corresponding changes in training effectiveness.

24 NUMBER OF PAGES:
0014

25 NUMBER OF REFERENCES:
0013

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Organization

36 REPORT TITLE:
The Pursuit of Validity in the Evaluation of Training Programs

37 REPORT AUTHOR:
Goldstein, I.L.

Key Number

38 REPORT DATE:
78/04/00

40 ORIGINATING ACTIVITY:
Department of Psychology, University of Maryland

52 PUBLISHER/SPONSOR:
Human Factors Society, Santa Monica, California

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 076
15 July 1978

Key Number

1 ACCESSION NUMBER: AD- 759 171

4 CITATION:
Woodruff, R.R.; Hagin, W.V. Dynamic Observation on T-37 Undergraduate Pilot Training (UPT) Link Trainers (T-4). Air Force Systems Command, Brooks Air Force Base, Texas, AFHRL-TR-72-61, February, 1973.

5 ABSTRACT:
PURPOSE: The purpose of the study was to evaluate the effects of dynamic observation in undergraduate pilot training (UPT).
METHOD: Sixty-two pilot trainees in the instrument phase of the T-37 syllabus served as Ss. Each of the eleven Ss in Group 1 (G-1) was to observe another trainee performing tasks during Link training, and later to be observed by another trainee while practicing the same tasks. Each of the eleven Ss in G-2 was similarly observed, but did not observe other trainees. The remaining Ss (G-3) neither observed nor were observed. Standard sorties (unspecified) were flown by each S, including a radar approach. Each S was rated on a 4-point scale by enlisted trainer instructors. In addition, questionnaires were completed by each S to determine his attitude toward dynamic observation.
RESULTS: Kruskal-Wallis Analysis of Variance (ANOVA) indicated that G-2 was superior (p LT. .02) on overall performance scores, while G-1 and G-3 did not differ. For radar approach, G-1 and G-2 were similar, and both were superior to G-3. The G-1 Ss who completed radar approach sorties improved significantly (p LT. .02) over their overall performance scores. Analyses of questionnaire results indicated that Ss did not feel that the presence of an observer affected their performance, and that they felt that the opportunity to observe other trainees was valuable, especially during the early stages of instruction.

6 AUTHOR'S CONCLUSION:
"Results indicate significant value in being observed as opposed to observing in all tasks studies . . . (and that) dynamic observation has value in procedural tasks (e.g., radar approach as opposed to overall motor performance)."

7 EVALUATION:
The authors noted four problems in experimental control: (a) Ss in G-1 were not always able to observe before being

Key Number

observed; (b) times between observing and performing a sortie varied from a week to less than a day; (c) all Ss did not complete the same number of sorties; and (d) a fourth group was needed who would observe but not be observed. A fourth group as in (d) might have resolved a question: Why was G-1 inferior to G-2 in overall task performance? The authors suggested that, because G-1 had been observers, they may have been affected less by being observed. However, this hypothesis belies the almost identical G-1 and G-2 performance on radar approach. In view of this inconsistency, it is not clear what the data imply regarding dynamic observation except that it apparently helps in some way.

10 AUTHOR'S RESEARCH SUGGESTIONS:
The motivating influence of being observed by a peer should be determined, and the kinds of tasks affected by dynamic observation in UPT should be identified.

14 DEPENDENT VARIABLES:
Overall performance in a Link trainer; radar approach performance in a Link trainer

15 INDEPENDENT VARIABLES:
Observing peer performance; peer observation of one's own performance

16 MEASUREMENT/STATISTICAL METHODS:
Kruskal-Wallis analysis of variance; Mann-Whitney U test

22 SYSTEM/CLASS:
Link trainer T-4

23 SUBJECT POOL:
Pilot trainees in instrument phase of T-37 syllabus

24 NUMBER OF PAGES:
0006

25 NUMBER OF REFERENCES:
0006

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experimenta/multiple variable

33 SUPPLEMENTARY NOTES:
AFHRL(FT)-TRM-20

076-2

Key Number

36 REPORT TITLE:
Dynamic Observation in T-37 Undergraduate Pilot Training (UPT) Link Trainers (T-4)

37 REPORT AUTHOR:
Woodruff, R.R.; Hagin, W.V.

38 REPORT DATE:
73/02/00

40 ORIGINATING ACTIVITY:
Flying Training Division, Williams Air Force Base, Arizona

44 CONTRACT/PROJECT/TASK:
1123/112303

48 REPORT NUMBER:
AFHRL-TR-72-61

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 077
15 July 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Gundry, J. The Effectiveness and Sophistication of Motion Cues Provided in Flight Simulators. PROCEEDINGS OF SYMPOSIUM: HUMAN OPERATORS AND SIMULATION, (Institute of Measurement and Control, London, England), 35-41, March, 1977.

5 ABSTRACT:
PURPOSE: The purpose of the report was to explore general issues in simulation by examining selected problems.
SUMMARY: In spite of a sizable literature regarding motion in flight simulators, very little is known regarding the training effectiveness of motion because very little of the research has involved transter of flight simulator training to performance in an aircraft. Yet, elaborate motion systems are purchased for training, and at costs that increase exponentially with degree of sophistication, i.e., fidelity, or the equivalence of simulator motion cues to those experienced in an aircaft. The continuing desire for complex motion systems is based on the assumption that training and operational environments should be comparable. However, it is not equivalence of environments that is needed, but equivalence of tasks to be performed. Thus, Task Commonality Analysis should be the basis of simulator design. Evaluations of motion effects typically do not specify task training requirements to be met, nor are motion system designs derived from them. Nevertheless, certain types of research evaluations are widely believed to support the value of motion: (a) Experienced pilots perform better in simulators with motion; (b) motion reduces sickness in simulators when visual cues of aircraft movement are provided; and (c) attitudes of users toward the simulators are more positive as motion fidelity is increased. However, (a) supports the value of motion only under the questionable assumption that pilot training in addition to experienced pilot performance is enhanced by motion conditions. Illustrative of the problems involved in this assumption is the fact that g-cues can be both advantageous and disadvantageous in the control of an actual aircraft. Hence, an unanswered question: When, and in what ways, might g-seats help or hinder training? As for (b), training effectiveness is not necessarily involved at all, and (c) is effective only to the extent it increases simulator use. Thus, the research task is to determine whether motion is even needed, and if so, what kinds and to what degree of sophistication. The lower

Key Number

limit of sophistication can be defined by determining thresholds of motion in simulator flight conditions (extrapolations from laboratory data for this purpose may not be valid). On the other hand, upper limits can be determined only by research using a transfer paradigm, and then only after trade-off analyses regarding costs effectiveness are completed.

6 AUTHOR'S CONCLUSIONS:
(a) The value of simulator motion cues must be determined in transfer of training experiments; (b) realism of simulator motion per se is not important in training, but training-operational task similarity is; (c) objectives of motion simulation should be derived from task requirements, and motion conditons, if any, should focus on task fidelity, not physical fidelity; and (d) present data are not adequate to specify motion requirements.

7 EVALUATION:
This report was often discursive, but the points were well made: Motion requirements should be anticipated through Task Commonality Analyses, and validated in transfer of training experiments. However, the emphasis on task fidelity appears overdrawn, depending on what is meant by the term. Even reduced-scale line drawings of consoles have been effective procedures trainers. Although the thrust of the points would not have been affected, a more thorough review of the experimental literature on simulator motion and a critical evaluation of research methodologies in this area would have helped define the research needs more clearly.

22 SYSTEM/CLASS:
Flight simulators with motion systems

24 NUMBER OF PAGES:
0007

25 NUMBER OF REFERENCES:
0022

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Critique

36 REPORT TITLE:
The Effectiveness and Sophistication of Motion Cues Provided in Flight Simulators

077-2

Key Number

37 REPORT AUTHOR:
Gundry, J.

38 REPORT DATE:
77/03/00

40 ORIGINATING ACTIVITY:
RAF Institute of Aviation Medicine, Farnborough, Hampshire, U.K.

52 PUBLISHER/SPONSOR:
Institute of Measurement and Control, London, England

56 TYPE OF PUBLICATION:
Presentation

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 078
24 July 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Browning, R.F.; Ryan, L.E.; Scott, P.G. Training Analysis of P-3 Replacement Pilot and Flight Engineer Training. Naval Training Equipment Center, Orlando, Florida, TAEG Report No. 10, December, 1973.

5 ABSTRACT:
PURPOSE: The purpose of the study was to devise an experimental syllabus for P-3 replacement pilot training that depended on simulator experience more than the current syllabus did, and to evaluate the syllabus in a field test.
METHOD: Preparatory to devising a syllabus, four instructor pilots (IPs) flew the 2F69D, performing all checks, procedures, and maneuvers usually performed in an aircraft during an existing Familiarization/Instrument syllabus. Each IP judged the acceptability of the 2F69D Operational Flight Trainer (OFT) as a substitute for in-flight training for each check, procedure, and maneuver. In addition, each of the 190 items in the "Pilot P-3 OFT and Aircraft Training Record" were analyzed in a terms of 2F69D training capabilities. An experimental syllabus was then established which provided, for each trainee, 9 hours of cockpit familiarization training (CFT) in a 2C23A static simulator, 29 hours of OFT training, and 11.75 hours in a P-3 aircraft. In contrast, the current syllabus provided 22 hours of OFT and 19.25 hours of P-3 training. All Ss were newly designated Naval aviators. Eighteen Ss comprising the control group (C) were trained according to the current syllabus. The 6 Ss in the experimental group (E), matched on the basis of undergraduate flight training scores, were trained using the experimental syllabus. Each S was rated on flight (F) and flight check (FC) performance by one of three IPs who did not train any of the experimental Ss.
RESULTS: C and E groups had identical means on F and C ratings (3.03 in each of the four instances). It was estimated that, for the current trainee load, the experimental syllabus would reduce training manpower costs by 254.8K and media cost by 3.729 M.

6 AUTHOR'S CONCLUSIONS:
(a) The potential value of part- and whole-task trainers such as the 2C23A and 2F69D is not understood; (b) the 2F69D has

Key Number

the capabilities to train most pilot and copilot tasks; (c) positive transfer of training occurred from devices 2C23A and 2F69D to the P-3; and (d) the experimental syllabus permitted pilots to gain in 5 P-3 flights what 7 flights in the current syllabus achieved.

7 EVALUATION:

The principal contribution of this study was in demonstrating that pilots trained using the new syllabus performed as well in the P-3 as those in the existing syllabus, even though the former had only 70% as many P-3 flights. Data were not available, however, that would show whether control Ss needed all the P-3 experience provided them. In fact, the four identical means of 3.03 for E and C on F and FC ratings suggest an asymptotic restriction for all groups, with little or no S variability. This inference is confirmed by the only statistical test reported: the mean rating for C of 3.00 vs. 3.04 for E on the first P-3 flight was "significant" beyond the .05 level. Furthermore, because of the matching of groups this test underestimated the significance of the difference. Therefore, because a difference of .04 was significant, S variability was almost non-existent, implying asymptotic performance. Hence, both E and C groups may have received more training than necessary.

8 COMMENTS:

The second subject of the title, flight engineer training, was addressed only tangentially in this report, and not thoroughly enough to be included in this abstract.

12 CROSS-REFERENCES:

Browning, R.F.; Copeland, D.R.; Lauber, J.K; Nutter, R.V.; Scott, P.G. Training Analysis of P-3 Replacement Pilot Training. Naval Training Equipment Center, Orlando, Florida, TAEG Report No. 5, 1972.

14 DEPENDENT VARIABLES:

P-3 overall instrument flight performance; flight check performance

15 INDEPENDENT VARIABLES:

Amount of simulator/aircraft training

22 SYSTEM/CLASS:

Flight simulators/2F69D and 2C23A

23 SUBJECT POOL:

Newly designated Naval aviators

Key Number

24 NUMBER OF PAGES:
0123

25 NUMBER OF REFERENCES:
0018

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

32 DESCRIPTIVE NOTES:
Final Report

36 REPORT TITLE:
Training Analysis of P-3 Replacement Pilot and Flight Engineer Training

37 REPO..T AUTHOR:
Browning, R.F.; Ryan, L.E.; Scott, P.G.

38 REPORT DATE:
73/12/00

40 ORIGINATING ACTIVITY:
Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
NTEC Work Assignment No. 1043

48 REPORT NUMBER:
TAEG Report No. 10

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

Key Number	
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 079
25 July 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Jacobs, R.S. Simulator Cockpit Motion and the Transfer of Initial Flight Training. Air Force Systems Command, Brooks Air Force Base, Texas, ARL-76-8/AFOSR-76-4, June, 1976.

5 ABSTRACT:

PURPOSE: This study had two purposes: (a) to determine whether simulator cockpit motion facilitated transfer of basic flight skills learned in the simulator to aircraft performance; (b) to determine whether cockpit motion cues played a directing or alerting role during training.
METHOD: From 500 civilians responding to an advertisement, a pool of 100 male, flight-naive Ss between the ages of 18 and 26 was selected who were "representative of Air Force undergraduate pilot trainees." From this pool, nine Ss were assigned to each of four groups over a period of several months in such a way that the Ns and running averages of flight aptitude scores for the groups were approximately equal at any one time. A control group (C) practiced a series of instrument-referenced flight maneuvers in a Piper PA-28R-200. The remaining three groups received similar instruction in a Singer-Link GAT-2 (GAT) simulator. One GAT group was trained without cockpit motion (NM), one with normal washout motion (WO), and the third with random washout motion (RW), in which 50% of the time the motion was normal in response to pilot input, and 50% of the time in opposite direction. All GAT groups completed a fixed number of trials in the GAT before attempting Piper training. Training in the Piper for all groups, including the original training for C, consisted of practice on each of 11 maneuvers, with each maneuver being mastered to the extent of two performances within error limits before progressing to the next one. All instructions to the Ss were presented either by video tape prior to flight, or by audio tape during flight. Two licensed pilots independently assessed each S's performance.
RESULTS: Total error counts in the GAT and in the Piper, and number of trials and minutes of practice to criterion in the Piper, were determined for each S as appropriate. These scores were transformed before analysis by adding unity to each and taking the logarithm. Group performance differences were tested for significance using analysis of covariance with aptitude score as the covariate, and with Y-intercept

Key Number

differences between regression lines reflecting mean differences. Data analyzed (and intercept ps) were as follows: total errors in GAT (.16); time to criterion in the Piper (.005) with C inferior to all GAT groups; number of trials in the Piper prior to criterion performance (.004), C again inferior; total errors in the Piper (.02), C inferior.

7 EVALUATION:

The significance tests given above under Results were selected from among numerous comparisons reported in the article. The remaining tests involved comparisons of pairs of groups, error scores separate by maneuvers, and regression slopes. The tests reported here were selected because in spite of the fact that not a single legitimate statistical test was used in this study, these four can be considered suggestive of interpretable findings to some extent. Three serious violations of required conditions for the analysis of covariance occurred. First, all groups were matched on aptitude, so the requirement of independent error variance was not met. The likely result of this violation was an underestimate of significance levels, although this outcome is by no means certain because of the necessary reduction in degrees of freedom from 32 to 8 which the author did not recognize. Second, intercept differences can reflect overall group differences only when regression slopes are homogeneous. Many slope comparisons showed "significant" differences among groups, and others "approached" significance. In fact, the author often drew inferences that assumed almost all slopes to be different. In such cases, the impossibility of concluding that means differ when Y intercepts do can be immediately apparent by considering two groups with equal means but heterogeneous slopes; the regression lines would cross at the means but would intercept the Y-axis at different points. This violation alone would make all intercept comparisons meaningless; and because the groups were not independent, the significance levels for all slope differences were likely higher than those reported. The third difficulty lay in the comparisons of extreme groups. For example, total errors in the GAT were analyzed for NM, WO, and RW, yielding a p of .16. The NM and WO, the extremes, were compared and a p of .02 obtained. Generally, in three dice throws, if only the highest and lowest values are compared, they will tend to differ "significantly." From an informal examination of the data, it appears nevertheless that simulator experience transferred to aircraft performance, and probably significantly so. It also appears that the normal washout group performed better than the other two GAT groups, but the realiability of this finding is questionable.

Key Number

8 COMMENTS:
This study was also reported in abbreviated form as: Jacobs, R.S.; Roscoe, S.N. Simulator Cockpit Motion and the Transfer of Initial Flight Training. PROCEEDINGS OF THE 19TH ANNUAL MEETING OF THE HUMAN FACTORS SOCIETY, 218-226, 15-16 October, 1975. Significance levels varied slightly, probably because the scores were not transformed, and the extreme group comparisons were omitted.

12 CROSS-REFERENCES:
See Comments

14 DEPENDENT VARIABLES:
Total errors in basic flight maneuvers; total trials to criterion; total practice time to criterion

15 INDEPENDENT VARIABLES:
No simulator motion; normal washout motion; random washout motion

16 MEASUREMENT/STATISTICAL METHODS:
Analysis of covariance; t test

22 SYSTEM/CLASS:
Flight simulator/GAT-2

23 SUBJECT POOL:
Flight-naive male civilians

24 NUMBER OF PAGES:
0079

25 NUMBER OF REFERENCES:
0025

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

36 REPORT TITLE:
Simulator Cockpit Motion and the Transfer of Initial Flight Training

37 REPORT AUTHOR:
Jacobs, R.S.

Key Number

38 REPORT DATE:
76/06/00

40 ORIGINATING ACTIVITY:
Aviation Research Laboratory, University of Illinois, Savoy, Illinois

44 CONTRACT/PROJECT/TASK:
F44620-76-C-0009/61102F/2313A4

48 REPORT NUMBER:
ARL-76-8/AFOSR-76-4

52 PUBLISHER/SPONSOR:
Air Force Systems Command, Brooks Air Force Base, Texas

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
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64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

079-4

ABSTRACT 080
27 July 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Browning, R.F.; Copeland, D.R.; Lauber, J.K.; Nutter, R.V.; Scott, P.G. Training Analysis of P-3 Replacement Pilot Training. Naval Training Equipment Center, Orlando, Florida, TAEG Report No. 5, 1972.

5 ABSTRACT:
PURPOSE: The purpose of the report was to evaluate current P-3 replacement pilot training programs with emphasis on the use of flight simulators.
SUMMARY: A team of two educational specialists, one psychologist, and two engineers conducted a literature review and made site visits to Replacement Patrol Squadrons. Curriculum evaluation included analyses of instructor selection and training, composition of the P-3 replacement pilot trainee population, group training, and flight training. As for the training programs in general, it was found that: P-3 pilot training was not cost-effective in that much training conducted in aircraft could have been conducted in operational flight trainers (OFTs); rotation of assignments of squadron management and instructor personnel made continuity of training programs difficult; training programs were not based on "need-to-know" material, and much time was wasted on irrelevant information; 2C23A Cockpit Familiarization Trainers and 2F69D OFTs were ineffectively or inappropriately used; new instructors were not adequately trained in instructional techniques or media; instructional media were not updated in a timely manner; classroom facilities were inadquate; instruction in use of various training media was inadequate, with no effective follow-up programs; maintenance of 2F69D OFTs was so lacking as to decrease training capabilities and increase training time. As for utilization of 2F69 and 2F69D devices specifically, it was found that: only one 2F69D could provide realistic simulation, and it needed "nominal restoration"; 2F69s needed "major rework and revalidation"; longitudinal acceleration/deceleration of 2F69Ds were too slow, while these characteristics were too fast for 2F69s; motion, navigation, and aural simulation systems were not used in either type device (one device had its motion controls taped); all P-3 OFTs examined were used only for cockpit procedures training; 2F69Ds were not used in the coupled mode; and maintenance personnel were not familiar with the dynatester so were not

Key Number

making effective use of this equipment. The authors made a number of recommendations, some of which were put into effect before this report was published. Recommendations follow, and those being put into effect are followed by (E). A permanent billet for an educational advisor should be established at each P-3 training squadron (E); a Navy-wide program for instructor selection and training should be established; existing instructor training programs should include training in OFT capabilities and use (E); a systematic program for devising new and updating old training media of all sorts should be established; OFT utilization should be increased to at least 16 hours per day; the present Naval Air Maintenance Training Group (NAMTG) four-day pilot training program should be replaced with system-operation and demonstration periods using NAMTG systems trainers; separate syllabi should be developed for first and second tour pilots; and selected airline, DoD, and industry training programs should be studied for possible application to Navy training. (See Comments.)

7 EVALUATION:
This report was excellent in scope, detail, and clarity of presentation. The multidisciplinary team made possible thorough evaluations of educational, human factors, and engineering aspects of P-3 training and training devices. The results documented a serious lack of utilization of OFT capabilities. The analyses became a foundation for a successful revision of the P-3 replacement pilot training syllabus as demonstrated in a field test (see Cross-References).

8 COMMENTS:
Included as Appendix A to this report was an analysis of training practices at five major airlines. This appendix was written as a separate, "stand alone" report. Because of the contrast in training practices with those reported above, a separate abstract of Appendix A was prepared (No. 081).

12 CROSS-REFERENCES:
Browning, R.F.; Ryan L.E.; Scott, P.G. Training Analysis of P-3 Replacement Pilot and Flight Engineer Training. Naval Training Equipment Center, Orlando, Florida, TAEG Report No. 10, December, 1973.
Also: Appendix A of the present report: Air Carrier Pilot Training: State-of-the-Art (Abstract No. 081).

22 SYSTEM/CLASS:
Flight simulators/2F69 and 2F69D

24 NUMBER OF PAGES:
0168

Key Number

25 NUMBER OF REFERENCES:
0066

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Description/evaluative

32 DESCRIPTIVE NOTES:
Final Report

36 REPORT TITLE:
Training Analysis of P-3 Replacement Pilot Training

37 REPORT AUTHOR:
Browning, R.F.; Copeland, D.R.; Lauber, J.K.; Nutter, R.V.; Scott, P.G.

38 REPORT DATE:
72/00/00

40 ORIGINATING ACTIVITY:
Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
Work Assignment No. 1022

48 REPORT NUMBER:
TAEG Report No. 5

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
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64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 081
27 July 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Browning, R.F.; Copeland, D.R.; Lauber, J.K.; Nutter, R.V.; Scott, P.G. Air Carrier Pilot Training: State-of-the-Art (Appendix A of Training Analysis of P-3 Replacement Pilot Training). Naval Training Equipment Center, Orlando, Florida, TAEG Report No. 5, 1972.

5 ABSTRACT:
PURPOSE: The purpose of this study was to review pilot training programs and simulator use at five major airlines for comparison to Navy P-3 replacement pilot training.
SUMMARY: Prior to visits to the airline pilot training centers, extensive checklists were developed for obtaining information regarding training management, trainee selection, instructional methods and media, and simulator usage, capabilities, and characteristics. Training managers enjoyed considerable prestige (all were either vice president or reported to a vice president). Instructors were of "noteworthy quality," having been carefully selected from among senior personnel on the basis of flight experience and teaching potential. Training programs for instructors at some centers included practice in task analyses and deriving "need-to-know" course objectives. Although instructors had inputs into training programs, close supervision of courses, and FAA (Federal Aviation Agency) monitoring, ensured standardization of training. Trainees comprised a highly select group (one airline selected only 88 from among 8000 applicants), and 65 to 85 per cent had military backgrounds. Training objectives were based on "need-to-know" tasks and knowledge analyses. Training programs, organized within a systems approach, began with classroom instructions utilizing a variety of media (sound slides, motion pictures, video tapes, mockups of cockpit panels, etc,), followed by training in subsystems of flight simulators. Ample provisions were made for individualized and self-directed instructions. Flight simulator capabilities were not significantly different from those used in Navy P-3 replacement pilot training. However, the level of simulator readiness maintained, the exploitation of simulator capabilities, and the extent of simulator use differed appreciably from that of P-3 simulators. Major simulator overhauls were completed yearly. Simulation of actual aircraft was sufficient, and training exploitation of the simulators was extensive enough

Key Number

for almost all FAA checkrides to be completed in the simulators. (One pilot trainee completed transition training and FAA checks in a DC-10 in only 1 hour, 11 minutes.) simulator utilization exceeded 98%, based on a 16-hour day, 7-day week. The principal basic design differences between airline and Navy flight simulators were that the former used off-the-shelf materials and parts, and that they also used operational rather than simulated equipment for the majority of instruments and controls. Elaborate motion systems were preferred by the airlines, and either film or camera model types of visual systems. (Computer-generated images were expected eventually to supplant other visual systems). Overall, the trend was toward greater simulator capability and fidelity.

7 EVALUATION:

This report was thorough in its analysis of airline pilot training and simulator use. There is no doubt that, as the authors stated, the Navy P-3 replacement training programs could benefit from adopting many of the practices characteristic of the airline programs, especially those relating to instructor training and simulator maintenance and exploitation. However, the enthusiasm toward airline practices evident in the report may be excessive. Many practices simply followed FAA requirements, or were designed to meet FAA requirements in economical ways. (Even so, the airlines felt that sophisticated simulators were cost effective in meeting the requirements.) Elaborate motion systems are yet to be shown more training effective than simple systems. Nevertheless, the authors presented an enlightening contrast between what the airlines accomplished with their simulators, and what Navy P-3 training failed to accomplish with comparable devices.

8 COMMENTS:

This appendix, a complete report in itself, was abstracted separately from the main report because its purpose and contents were different.

12 CROSS-REFERENCES.

See full report in Citation. Also see Browning, R.F.; Ryan, L.E.; Scott, P.G. Training Analysis of P-3 Replacement Pilot and Flight Engineer Training. Naval Training Equipment Center, Orlando, Florida, TAEG Report No. 10, December, 1973.

22 SYSTEM/CLASS:

Flight simulators

24 NUMBER OF PAGES:

0051

Key Number

25 NUMBER OF REFERENCES:
0001

28 RESEARCH METHOD:
Description/evaluative

36 REPORT TITLE:
Air Carrier Pilot Training: State-of-the-Art (Appendix A of Training Analysis of P-3 Replacement Pilot Training)

37 REPORT AUTHOR:
Browning, R.F.; Copeland, D.R.; Lauber, J.K.; Nutter, R.V.; Scott, P.G.

40 ORIGINATING ACTIVITY:
Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
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48 REPORT NUMBER:
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52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
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ABSTRACT 082
16 August 1978

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1 ACCESSION NUMBER:

4 CITATION:
Charles, J.P.; Johnson, R.M. Automated Weapon System Trainer: Expanded Adaptive Module for Basic Instrument Flight Instruction. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN 74-C-0141, August, 1977.

5 ABSTRACT:
PURPOSE: The objectives of the study were to analyze the current instrument training syllabi for fixed wing high performance aircraft and the role of a simulator in support of the syllabus, and to develop and demonstrate an application of automated adaptive technology to the syllabus.
SUMMARY: Reviews were made of syllabi for pilot training, replacement instrument training, and readiness training. The syllabus for advanced jet instrument training was selected to demonstrate automated adaptive technology development because it included the broadest range of flight maneuvers, the maneuvers were more precisely defined, and the syllabus included simulator training objectives. Particular maneuvers selected for development were: Precision Maneuvers--turn pattern, vertical S-1, vertical S-2, and vertical S-3; Confidence Maneuvers--aileron roll, loop, Immelmann, and split S; and Air-to-Air Maneuvers--beam attack, forward quarter attack, and head-on attack. Eight variations of each separate maneuver were developed based on variations in aircaft weight, turbulence, speed, altitude, and direction of entry into maneuver. Each maneuver was broken down into successive segments. Three classes of measures were identified for automatic monitoring during the segments: maneuver performance as revealed by instrument readings, control performance (sideslip, aileron stick input, and elevator stick input), and cognitive (procedural) performance. A serious problem had to be solved before the syllabus could be adapted to individualized instruction. Each maneuver contained new control tasks, and (with some exceptions) there was no earlier, simpler training stage of a maneuver to which to send a student having difficulty. The problem was circumvented, at least to an extent, through analyses of the three kinds of measures obtained during each maneuver segment. Thus, it was possible to idenfiy the type of problem (procedural, control) and the task involved for input to the adaptive algorithm. By design, feedback was provided to the student during and at the end of

Key Number

each maneuver, and at the end of each training flight. Subsystems included graphic cathode ray tube displays to describe each maneuver to a student prior to his attempted performance, instructor console computer records of student training history and detailed performance data for each maneuver segment, and modular software which could readily be used with other trainers.

6 AUTHOR'S CONCLUSIONS:
(1) "Operational syllabi and training operations provide sufficient data to design and implement automated-adaptive training capability for ground based (including operational flight) trainers." (2) "Performance measures which sample knowledge, control skill and task performance are feasible . . . (and permit the diagnosis of) students' performance acquisition problems." (3) "Construction on-line of an individualized and remedial syllabus based on the type of performance problem encountered by the student is feasible." (4) Further integration (than equipment used permitted) of the instructor into the training system will be required for full exploitation of computer assisted diagnosis and remedial syllabus generation. (5) "Segmentation of complex pilot training tasks for computer syllabus control is feasible . . ."

7 EVALUATION:
The problems of individualizing automated instruction due to the discrete nature of many tasks is fairly common in military training. The authors presented a convincing case that segmentation of tasks and judicious choices of performance measures to be monitored can circumvent this problem, at least to the extent that meaningful individualization of some syllabus content is possible. An empirical evaluation of their syllabus is needed, however, to establish its actual value and identify needed adjustments.

8 COMMENTS:
The title given in the Citation was the one used for the published form. The original report was entitled "Automated Weapon System Trainer: Expanded Module for Basic Instrument Flight Maneuver (sic)."

10 AUTHOR'S RESEARCH SUGGESTIONS:
The adaptive syllabus should be evaluated using the Device 2F90 Operational Flight Trainer. Also, a study should be undertaken to "explore" further multi-component scoring algorithms, and forcing specified flight parameters to maintain constant values throughout maneuvers. Finally, the student briefing and feedback systems as conceived in this study should be evaluated.

Key Number

22 SYSTEM/CLASS:
Operational flight trainers

24 NUMBER OF PAGES:
0200

25 NUMBER OF REFERENCES:
0023

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Logical analysis and description

36 REPORT TITLE:
Automated Weapon System Trainer: Expanded Adaptive Module for Basic Instrument Flight Instruction

37 REPORT AUTHOR:
Charles, J.P.; Johnson, R.M.

38 REPORT DATE:
77/08/00

40 ORIGINATING ACTIVITY:
Appli-mation, Inc., San Diego, California

44 CONTRACT/PROJECT/TASK:
NAVTRAEQUIPCEN N61339-74-C-0141/Task 2753-03P01

48 REPORT NUMBER:
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49 OTHER REPORT NUMBER:
AISR 376

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
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64 LOCATION SYMBOL:

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65	LOCATION FILE:
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ABSTRACT 083
16 August 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Cox, J.A.; Wood, R.O., Jr.; Boren, L.M.; Thorne, H.W. Functional and Appearance Fidelity of Training Devices for Fixed-Procedures Tasks. Human Resources Research Office, Alexandria, Virginia, Technical Report 65-4, June, 1965.

5 ABSTRACT:
PURPOSE: The purpose of the study was to compare the effects of varying degrees of functional and appearance fidelity upon learning procedures to operate the Section Control Indicator console (SCI) of the Nike Hercules guided missile system. METHOD: The experiment was comprised of six sets of comparisons of levels of fidelity upon SCI operation training. Ss for the first five comparisons were drawn from a parent group of trainees for Artillery Automatic Weapons Crewmen Military Occupational Speciality (MOS 192) rather than MOS 177, the classification for SCI operation, to ensure no prior experience with the SCI. The parent group was selected, however, so that the distribution of General Technical (GT) scores from Army Aptitude Area scores matched that of MOS 177 trainees. Ss for the sixth comparison were MOS 177 trainees. Groups used in each of the first five comparisons were also matched on GT scores, while those in the sixth comparison were as constituted in an existing training program. In all comparisons each S was to learn a fixed procedural sequence involving 39 switch operations, monitoring 36 signals, responding verbally on 11 occasions, and recording a time on 23 occasions. In each of the first five comparisons, Ss were trained in 5-man groups under one of a variety of fidelity conditions, and each of three instructors in a comparison taught under each fidelity condition. Twelve devices (Ds) were used: D-1, same size and shape as an SCI with all components of high fidelity and functioning; D-2, same as D-1 except only switches (not lights, meters, etc.) operable; D-3, same as D-1 but with no part operable; D-4 cardboard panel painted to resemble D-1 closely; D-5, full-size photograph of D-1, and D-6, full-size black-and-white line drawing of D-1, each in a high fidelity housing; D-7, the D-2 panel in a high fidelity housing; D-8, the D-2 panel in a plywood box; D-9, the D-2 panel mounted on a wooden frame without housing; D-10, a full-size black-and-white line drawing as in D-6, but with increased lettering size; D-11, a reproduction of D-10,

Key Number

but at one-half size; D-12, a reproduction of D-10 but at one-twentieth size. For the first five comparisons (Cs), the fidelity dimension, number of groups/size of each, and the devices used, one per group, are given in order. C-1: functional fidelity; 3 groups/20 Ss; D-1, 2, and 3. C-2: two- vs. three-dimensional representations, 4 groups/20 Ss; D-1, 3, 5, and 6. D-3: housing fidelity; 3 groups/15 Ss; D-7, 8, 9, C-4: panel fidelity; 3 groups/15 Ss; D-1, 2, and 4. C-5: size of representation; 4 groups/15 Ss; D-10, 11, 12, but with D-10, 11, and D-11, 12 comparisons made independently. During training using reduced fidelity devices, signals were presented orally by the instructors as necessary, and Ss verbalized their actions if the device was not adequate for their performance. Data for the sixth comparison were obtained at a training site, with Ss and instructors as assigned by the unit. D-6 was used with 36 Ss taught by 3 instructors, each using is own preferred method. An actual SCI and 4 instructors were used with 35 other Ss. Dependent variables for all comparisons were number of errors made in a criterion trial, and time required to complete a standard number of specified training trials.

RESULTS: Data from C-1 through C-5 were analyzed using analyses of variance (ANOVA) with covariance adjustments for GT scores, except for training time in C-1 in which the covariance adjustment was not used to compare D-10, 11 groups, and to compare D-11, 12 groups. No statistically significant result was found in any comparison.

6 AUTHOR'S CONCLUSIONS:

Reduced fidelity along any dimension included in this study did not affect the learning of the procedural sequence.

7 EVALUATION:

The experimental controls were adequate for the purpose of the study, but matching groups rendered both ANOVA and covariance ANOVA inappropriate as used. With covariance, however, the significance was probably overestimated, so insofar as even a long lock-step procedural sequence is concerned, this study showed that under the conditions of laboratory training used, and field training with associated lack of control of instructor teaching procedures, devices of very low fidelity can be training effective. The qualification regarding the "conditions of laboratory (and field) training used" was added because of the magnitudes of number of correct responses on criterion trials. Median errors for the 17 groups in C-1 to 5 ranged from 10 down to less than 3 percent, with substantial skew toward more errors due to only a very few Ss. Hence, near asymptotic performance was attained before criterion data were collected, rendering group differences unlikely. Even

Key Number

so, an important point can be made: Training per 5-trainee group required substantially less than three hours on the average, and it was established that given even this small amount of time, device fidelity was not necessary. Thus, it is more or less moot whether even less training effort, preparing Ss to below asymptotic levels, might have resulted in degree of fidelity showing differential effects.

14 DEPENDENT VARIABLES:
Number of correct steps performed in a lock-step procedural sequence; time required to complete a standard set of training trials

15 INDEPENDENT VARIABLES:
Degree of fidelity of a Section Control Indicator console along dimensions of: function; housing; size; and two- vs three-dimensional representations

16 MEASUREMENT/STATISTICAL METHODS:
Analysis of variance; analysis of covariance; t tests

22 SYSTEM/CLASS:
Control console simulator/Section Control Indicator

23 SUBJECT POOL:
Artillery Automatic Weapons Crewmen trainees; Missile Crewmen trainees

24 NUMBER OF PAGES:
0044

25 NUMBER OF REFERENCES:
0016

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/multiple variable

36 REPORT TITLE:
Functional and Appearance Fidelity of Training Devices for Fixed-Procedures Tasks

37 REPORT AUTHOR:
Cox, J.A.; Wood, R.O., Jr.; Boren, L.M.; Thorne, H.W.

40 ORIGINATING ACTIVITY:
Human Resources Research Office Divison No. 5 (Air Defense), Fort Bliss, Texas

083-3

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44	CONTRACT/PROJECT/TASK: Department of the Army Contract DA-44-188-ARO-2/DA Proj 2J024701A71203
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52	PUBLISHER/SPONSOR: Human Resources Research Office, Alexandria, Virginia
56	TYPE OF PUBLICATION: Technical report
60	DISTRIBUTION STATEMENT: Unlimited
64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

ABSTRACT 084
22 August 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:

Boyles, W.R. Historical Review of Inflight Measurement of Pilot Proficiency. Appendix B in Forrest, F.G. Development of an Objective Flight Test for the Certification of a Private Pilot. DOT Report DS-70-17, May, 1970.

5 ABSTRACT:

PURPOSE: The purpose of the review was to examine representative research on inflight measurement of pilot proficiency prior to 1970.

SUMMARY: Research prior to 1940 concentrated on the selection of pilots, with little concern for the analysis of a pilot's job and no concerted effort to measure pilot performance. Instructor rating scales that had been used were useless for discriminating among students. Work had begun, however, on graphic and photographic recorders for use in training planes. Reliability of inflight performance measures became a concern during the early 1940s. The "Manual of Standard Check-flight Procedures for Civilian Pilot Training," a product of research done at the University of Pennsylvania, appeared in 1943. Along with some provisions for subjective data, it emphasized the use of a series of standard flights, observations of aircraft control techniques, and motion photography of the instrument panel, primary flight controls, and the pilot's arms and hands. The "Purdue Scale for Rating Pilot Competency" appeared about the same time. The latter scale utilized subjective ratings, but was "shown" to differentiate between good and poor pilots. A factor analysis of the Purdue scale yielded skill, judgment, and emotional control as the primary factors. The "Ohio State Flight Inventory," developed during this same period, also utilized subjective evaluations, but with emphasis almost entirely on pilot skills as opposed to judgmental considerations. By 1945, the lack of reliability in these and other procedures for rating pilot performance had become a primary point of concern. More use was made of graphic and photographic recordings, but an additional problem of reliability of measures had emerged. Many previous studies had determined reliabilities by the split-half method, applied to data from a single flight. However, students varied considerably from one flight to another, a circumstance that yielded very low test-retest reliabilities even for

Key Number

measures based on graphic and photographic recordings. State-of-the-art assessments began to focus on the underlying measurement difficulties by the late '40s. Whether subjective or objective, measures should be obtained under standard conditions: (1) A work sample should be defined so that all pilots would be rated on the same type of effort; (2) instructors should be carefully trained to observe critical pilot behaviors, with frequent refresher training to ensure instructor constancy in criteria and judgments; (3) the task to be rated should be clearly defined to the student; (4) objective measures should be obtained; and (5) to the extent possible, inconsistency of performance due to variations among aircraft and weather conditions should be avoided. Also by the mid '40s, establishing the validity of measures of pilot performance was seen as a necessary step in developing measures. Criterion data for validity studies could be derived from expert judgments of pilot performance, and from groups of aviators with recognizable differences in flying ability. By the late '40s, two techniques had come into use for identifying critical aspects of flight performance, thus permitting reductions in the typically large numbers of component skills (and indicators thereof) that had been used in rating scales: (1) job analysis techniques; and (2) the critical incident technique. Both types of techniques were often used jointly, focusing on pilot responses that contributed to aircraft accidents. Pilot errors, and thus by inference responses of concern in pilot ratings, were of most concern when they related to establishing and maintaining glide slope, incorrect operation or failure to operate controls and switches, failure to maintain safe airspeed and altitude, and recovery from stalls and spins. State-of-the-art assessments by 1950 pointed out that: (1) subjective ratings of work samples were in common use, focusing both on specific and general aspects of flight performance; (2) brief descriptions of a pilot's performance often accompanied the ratings; (3) rating scales ranged from 2 to 100 assignable points; (4) on some scale items "points to be considered" were provided to guide the rater; (5) overall proficiency ratings were generally assigned independently of separate maneuver ratings; (6) ratings were made after the checkride had been completed; and (7) ratings were often based on different aspects of individual pilot performance. The methods as used had not produced satisfactory reliabilities among independent raters, they did not discriminate between relative proficiencies in different aspects of flying, they did not provide sufficient ranges to discriminate fully among all levels of flying ability, and ratings obtained lacked validity for predicting success in later stages of training. Special observations regarding graphic and photographic recordings included their

Key Number

"excessive" cost, the need to equip a plane specially for recording, and the inconvenience of having to process recordings before they could be used. In addition, such recordings were not measures themselves, but had to be interpreted. Neither did they necessarily provide ride-ride (test-retest) reliability. Perhaps more important: Recordings showed what the plane was doing, but not what the pilot was doing. One writer, after a thorough study of the 1950 state-of-the-art, stated the following "principles" to be followed in developing pilot performance measures: (1) Because of their particular competencies, research-trained psychologists should be responsible for developing such measures; (2) test developers should work as a team with test users, and in such a way as to impress on the latter the need for reliable and relevant data; (3) measures should be derived from critical job elements, i.e., those that make the difference between success and failure; (4) deliberate programs and schemes should be established for obtaining critical incident data; (5) in the absence of an ultimate criterion, job analysis/critical incident data should be used to ascertain rational validity of measures; (6) relevance of proficiency measures should not be pursued to the point that their administration would exceed limits of economy and safety during flight; (7) only test-retest methods across days should be used to determine reliability of measures; (8) measures should require examiners to make careful, systematic observations, using objective references when possible; (9) measures should be obtained under standard conditions; (10) examiners should be thoroughly trained in the use of measures; (11) particular training requirements per se should be a basis for proficiency measures only if they are consistent and relevant; (12) scoring procedures should be as simple as possible: (13) operating personnel should be convinced that they are members of the measuring team, not victims of it; and (14) attitudes of operating personnel at large, not just those immediately available, should be considered in developing measures. By the mid '50s, test-retest reliability (and validity or relevance to some extent) had become a primary concern, and objectivity of measures was seen as a means of enhancing reliability. "Performance Record Sheets" (PRS) were developed, based largely on the syllabus for primary Air Force flight training. The PRS specified objective conditions for making observations and objective criteria for assigning scores. The "Sensitive Indicator Technique," based on instrument readings, and the "Performance Proficiency Scale," an objectively anchored subjective measure, both appeared in 1955. In one use of these scales it was found that a sufficient relation existed between performances in a B-47 and in a B-47 simulator to "justify the use of simulator grades for

Key Number

(student) elimination purposes." After the mid '50s, emphasis continued to be upon objectivity of measures, and systematic research regarding them. The "Pilot Performance Description Record" (PPDR) developed in the early '60s, and the shortened form, "Daily Progress Record," (DPR) in the late '60s, resulted from efforts by the Human Resources Research Organization. Not only were measuring procedures clearly standardized in these instruments, but objectivity was emphasized as much as possible. Furthermore, research with the PPDR and DPR revealed that a simple total error score correlated very highly (above .95) with other scores such as error profiles, making the specific determination of the latter unnecessary. With such an instrument and simple scoring requirements, the scoring workload on the examiner could be reduced, permitting more of his attention to matters of safety. Because scoring was possible without neglecting the status of the aircaft, the instructor was more likely to make accurate observations and record them properly than would have been the case with complicated scoring schemes.

6 AUTHOR'S CONCLUSIONS:

(1) "The general principles (listed above for developing measures) constitute a valuable guide for researchers . . ." (2) "In general, the trend has been toward objective measurements, and this is justified by findings of greater reliability . . ." (3) "Most systems in general use . . . have combined objective and subjective items." (4) Simple scoring methods (e.g., error count) are satisfactory for rating fixed-wing performance, but more complex methods may be required for rotary-wing performance. (5) The demand by instructors for rating methods that do not violate conditions necessary for safety requires that scoring methods be simple, and that the instructors be trained in their use so that a minimum amount of instructor time will be needed for scoring. And (6) conditions of flight and unique characteristics of individual aircraft render precise inflight measures unlikely.

7 EVALUATION:

The author's intent was to discuss representative research in the development of pilot performance measures, not to provide an exhaustive review. He fulfilled the intent well, and the result should be of interest to anyone concerned with measuring pilot performance. The focus of attention, however, was upon the reliability of measures. Issues of validity or relevance appeared only occasionally, and then were not pursued. Apparently it was assumed by the authors of the reports reviewed, and possibly by the author of this review, that the job analysis and critical incident techniques used to identify critical pilot behaviors assured validity. However,

Key Number

except for the expert judgment of pilots used in selecting critical behaviors, and that of examiners in making subjective overall ratings of students, criteria for ascertaining the validity of individual scale items were generally lacking. Even so, no item analyses were reported (some were done in the research covered, however) that showed concurrence even of individual items among themselves or with expert overall evaluations. This apparent lack of concern with establishing empirically the validity of individual scale items characteristizes current research as well as that of 1970 and before. The danger in ignoring validity is that while the steady trend toward objectivity may result in highly reliable measures, important relevance considerations may be neglected in favor of pursuing a preconceived level of objectivity, a level that may not be possible for some worthy measures.

14 DEPENDENT VARIABLES:
Inflight pilot performance

24 NUMBER OF PAGES:
0046

25 NUMBER OF REFERENCES:
0051

28 RESEARCH CLASS:
Status Study

29 RESEARCH METHOD:
Historical

36 REPORT TITLE:
Historical Review of Inflight Measure of Pilot Proficiency

37 REPORT AUTHOR:
Boyles, W.R.

38 REPORT DATE:
70/05/00

40 ORIGINATING ACTIVITY:
Human Resources Research Organization, Alexandria, Virginia

48 REPORT NUMBER:
DOT Report DS-70-17

52 PUBLISHER/SPONSOR:
Human Resources Research Organization, Alexandria, Virginia/Department of Transportation

Key Number

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64	LOCATION SYMBOL:
65	LOCATION FILE:
66	LAST DATE OF UPDATE:

084-6

ABSTRACT 085
23 August 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Wheaton, G.R.; Rose, A.M.; Fingerman, P.W.; Korotkin, A.L.; Holding, D.H. Evaluation of the Effectiveness of Training Devices: Literature Review and Preliminary Model. U.S. Army Research Institute for the Behavioral and Social Sciences, Arlington, Virginia, Research Memorandum 76-6, April, 1976.

5 ABSTRACT:
PURPOSE: The purpose of the report was to develop the foundations for, and present a preliminary statement of, a model for predicting transfer of training (TOT) value of a training device.
SUMMARY: The foundations for a model to predict TOT were developed through critical examination of existing methods, derivation of consensus principles regarding theories of TOT, and synthesis of experimental data regarding TOT. Existing methods were lacking in that (1) most were prescriptive rather than predictive; (2) most addressed only the design of training content; (3) almost all focused on acquisition of learning rather that TOT, and none covered both aspects well; (4) flexibility of the methods was limited because each tended to focus on a single level of description (moleculer or molar); (5) definitions of terms and procedures for obtaining data tended to be complex, cumbersome, and often ambiguous; (6) analyses were too often limited to only one or two dimensions (e.g., device-actual equipment similarity) and ignored the multi-dimensional nature of problems; (7) none of the methods was sufficiently concerned with quantifications; and (8) empirical support for the procedures and underlying rationales was not adequate. However, taken as a group, they did identify the range of dimensions that should be considered: (1) Task analyses should be made at both molar and molecular levels; (2) acquisition of learning should be analyzed, especially those aspects requiring special training or those necessary for achieving transfer; (3) principles of learning and training techniques should be adapted to the acquisition of each type of learning; (4) TOT principles should be incorporated in acquisition training: (5) syntheses of training issues should be provided which emphasize procedures and criteria for evaluating dimensions of a model. Two types of theories of TOT were identified, both of which were reflected in various ways in the methods reviewed earlier.

Key Number

One type emphasized skill acquisition, and largely assumed that the skills would mediate TOT to operational contexts. The second focused on establishing learning- and operational-context similarity as a mechanism for assuring TOT. The similarity approach seemed more viable because similarity could be operationally defined. Nevertheless, difficulties were apparent: Similarity relations, at least as presently conceived, do not cover all variables relevant to training; similarity theories have depended largely on verbal learning experiments for support, and their value in military training may be hard to establish a priori. The skill-based mediation theories can complement similarity theories provided the mediational elements promoting TOT can be identified. Even so, these theories in combination fail to account for all variables and conditions known to affect TOT, such as (1) amount of practice; (2) task-intrinsic versus augmented feedback; (3) stimulus parameters other than similarity; (4) situational as opposed to stimulus variations; (5) stimulus predifferentiation; (6) learner characteristics; (7) task difficulty; (8) task organization; (9) task time-sharing; (10) part-whole interrelations; (11) adaptive training; and (12) previous experience. After reviewing research on the effects of these variables, three groups of principles required for efficient training were identified: (1) training management and control techniques--(a) relevant subordinate tasks must be mastered before their transfer effects can aid learning complex tasks; (b) a variety of previous knowledge enhanced TOT; (c) drill is effective in simple tasks, but instruction in principles is more effective for complex tasks; (d) a task should be taught as a whole if its steps are closely coordinated; (e) there are advantages, however, in practicing different task components separately if each is largely independent of the others; (f) errors should be prevented through guidance during early trials; (g) guidance is most efficient in teaching complex sets of actions; (h) the order in which tasks are learned should be determined jointly by their complexity and level of mastery to be attained before proceeding to the next task; and (i) more time should be allotted for improvement in performance for tasks with many subtasks than for less complex ones; (2) conditions of first task (that to be transferred) performance--(a) practice should occur in as wide a variety of applicable situations as possible; (b) continuous or massed practice facilitates mastery of complex, meaningful material and the coordination of rhythmic activity; (c) spaced practice is more efficient if only actual time spent in practice is counted; (d) effectiveness of spaced practice depends on what is done between practice periods--do the other activities facilitate or interfere with retention? (e) older trainees prefer massed practice; (f) brief rests

Key Number

during practice sessions are as effective as long ones; (g) "mental practice" (rehearsing in imagination) can be substituted for some practice trials; and (h) the learner should not be passive but actively involved in decisions and choices; (3) conditions of feedback--(a) rate of improvement depends upon precision of knowledge of results (KOR); (b) delay of KOR has little or no effect on acquisition; (c) increasing up to a point the interval between KOR and subsequent practice improves performance level during acquisition; (d) type of activity during pre- or post-KOR delay does not affect acquisition; (e) lack of KOR is detrimental during moderate or lower levels of acquisition; (f) the effect of delayed KOR is poorer performance during acquisition if learner engages in deliberate verbal or motor activity than if he rests (cf. 3-d above, also Evaluation); (g) if the learner rests during delay in KOR, then when KOR is withdrawn the effect is not different than when immediate KOR was withdrawn; (h) activity during post-KOR interval lowers performance when KOR is withdrawn; (i) learning can progress without KOR if a "relatively large amount" of training has already occurred; (j) pre-training during which augmented feedback (i.e., feedback not intrinsic in performance effects) is provided must not make learner dependent on the augmented feedback; (k) information regarding the effectiveness of actions should be available quickly (cf. 3-b, above; also Evaluation); (l) KOR is most effective when it is clearly and simply related to an action, and when it identifies discrepancies between actions and what is required; (m) learners should be taught to learn in and of itself. The preliminary model presented for predicting TOT had two dimensions training content and training process. As presented, training content is to be determined through job/task analyses, the results of which can be further classified according to behavioral categories. (Presumably, the categories may more readily imply training processes.) The training process dimension had three major divisions: (1) Appropriateness--"commonality" of training device tasks and those in operational setting, "criticality" of content for operational performance, and "similarity," i.e., fidelity, of device representation of operational tasks; (2) Efficiency--What does a trainee have to learn (need to know)? How much does he know at the beginning of training? How difficult are various tasks to learn? What standards should be achieved? How should he be taught? and (3) Effectiveness--How successful was the training? The questions appearing after (2) and (3) were raised, but not answered, in the discussion of the preliminary model. A future report was to answer these questions by incorporating the principles of transfer given above.

Key Number

7 EVALUATION:

This report was an excellent contribution to the literature, and for two reasons. First, it compared and contrasted in a succinct, critical manner several ways of trying to determine a priori the value of training devices. Second, it presented a detailed summary of the effects of various conditions and variables on transfer of training. Within the scope of the report, both topics were covered well. Two tables cross-referencing transfer variables with individual research reports alone make this report a valuable reference. There were shortcomings, nevertheless, and while some were serious, they did not detract appreciably from the overall excellence of the material. Certain of the shortcomings are detailed here because they related to numerous research efforts on transfer-related topics that are generally omitted in discussion of TOT as it related to military training. First, Gestalt theories of TOT were not mentioned. This lack per se is not of consequence. However, the reason why a leading Gestalt theorist, in his presidential address to the American Psychological Association, rejected his own previous explanation of TOT is of consequence. He cited the phenomenon variously referred to as "learning to learn" and the "formation of learning sets" or "discrimination learning sets." This phenomenon provides a framework for defining, or at least conceiving, parameters that would make TOT variables such as past experience, learner characteristics, even stimulus parameters (including similarity) more meaningful operationally. Research in this area has been invaluable for conceptualizing social (really, learning) deprivation and potential remedies. Major advantages of learning-set approaches to training include empirically based prescriptions for practice, tasks to be practiced, and standards of task performance, issues which can be conceived only intuitively within the frameworks discussed by the authors. Completion of the proposed model for predicting TOT will require such prescriptions. Different, though related, bodies of research literature that were also omitted in the reviews concerned interference-based forgetting and discrimination learning. These concepts can partially resolve contradictions pointed out above of TOT principles presented by the authors (3-b and 3-k; 3-d and 3-f). Particular research data upon which these conflicting statements were based were not reported, but these confusions have been evident for decades. As has been shown, the effects of what happens during and after KOR delays depend at least partly upon interference from extraneous activities, and the interference in turn varies with the extent of discrimination or differentiation of the extraneous tasks from the one being learned. Furthermore, discriminations derive from (often) life-long habit systems of processing information, systems

Key Number

that can be easily conceived in a learning set framework. The summary of information regarding TOT presented by the authors, valuable though it was, suffered from over-simplicity of definitions and conceptions of roles of variables. At least part of the confusion could be removed, and better prescriptive guides for training devices could be forthcoming, if the more analytically productive concepts of interference and discrimination had guided the analyses. A related confusion also could have been avoided: KOR in many of the studies cited, and ones from which the authors' principles were drawn, would have to be considered augmented feedback by the present authors' definitions of the terms. If so, principle 3-j in the context of the report is at odds with most statements regarding KOR. There is no contradiction here, but no interpretable meaning either. Finally, the TOT prediction model was unintelligible as presented. Subclassifications of "Training Process" often had no ostensible identification as such. Insofar as the contents of the model matrix were identified, they were standard steps in developing training device designs. Hence, the principal interest that the model may have relates to the future systematic incorporation of transfer principles into device design and use. This formidable task was yet to be completed. (However, see Cross-References.)

8 COMMENTS:
Although only 83 references were actually cited in the report, 496 entries appear in a general bibliography.

12 CROSS-REFERENCES:
Wheaton, G.R; Fingerman, P.W.; Rose, A.M.; Leonard, R.L. Jr. Evaluation of the Effectiveness of Training Devices: Elaboration and Application of the Predictive Model. U.S. Army Research Institute for the Behavioral and Social Sciences, Arlington, Virginia; Research Memorandum 76-16, July, 1976. Also, see by these authors: Evaluation of the Effectiveness of Training Devices: Validation of the Predictive Model. U.S. Army Research Institute for the Behavioral and Social Sciences, Arlington, Virginia, ARI Technical Report TR-76-A2, October, 1976. See also Abstracts 090, 091, and 092.

14 DEPENDENT VARIABLES:
Transfer of training

22 SYSTEM/CLASS:
Training devices

24 NUMBER OF PAGES:
0134

Key Number

25 NUMBER OF REFERENCES:
0083

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Organization

36 REPORT TITLE:
Evaluation of the Effectiveness of Training Devices:
Literature Review and Preliminary Model

37 REPORT AUTHOR:
Wheaton, G.R.; Rose, A.M.; Fingerman, P.W.; Korotkin, A.L.;
Holding, D.H.

38 REPORT DATE:
76/04/00

40 ORIGINATING ACTIVITY:
American Institute for Research, Washington, D.C.

44 CONTRACT/PROJECT/TASK:
DAHC 19-73-C-0049/2Q763731A762

48 REPORT NUMBER:
Research Memorandum 76-6

52 PUBLISHER/SPONSOR:
U.S. Army Research Institute for the Behavioral and Social
Sciences, Arlington, Virginia

56 TYPE OF PUBLICATION:
Research memorandum

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 086
24 August 1978

Key Number
1 ACCESSION NUMBER:

4 CITATION:
Gum, D.R.; Albery, W.B. Time-Delay Problems Encountered in Integrating the Advanced Simulator for Undergraduate Pilot Training. JOURNAL OF AIRCRAFT, 14(4), 327-332, April, 1977.

5 ABSTRACT:
PURPOSE: The purpose of this report was to discuss transport delay problems encountered in the integration of computer image generation (CIG) with the Advanced Simulator for Undergraduate Pilot Training (ASUPT).
SUMMARY: 100 msec are required for the ASUPT CIG to produce a TV picture. This (transport) delay is due to the time required to input angular and transitional data, extract corresponding three-dimensional (3-D) data from data base storage, develop a 2-D display model, and produce TV raster scan-line elements in sequence. Two types of compensation for this delay were considered. The first used a second-order Adams numerical integration of data in a given frame to predict the position of the simulator in the next frame (single-interval lead, or SIL). The second used Taylor series extrapolations, backward as well as forward, from the SIL. The compensations were adjusted to lead positional outputs to instruments by a value equal to the CIG transport delay. Analogous compensations were not possible for the motion system delays, however, because the SIL technique is not readily adaptable to the flight model accelerations used in the ASUPT. Instead, two types of software drives were tested on the motion systems. The first determined platform acceleration according to subjective preferences of test pilots for rotational and translational cueing. It was found that when a pilot pulled aft on the stick with maximum force, 100 msec were required for the total stick deflection, and approximately 350 msec total for the motion platform to begin measurable acceleration. The second software drive, which eliminated the translational cueing, provided a lag of only approximately 129 msec, "perhaps the best response possible from the ASUPT motion system." (However, the platform is normally driven with the first software, and increasing frequency response and gain as with the second software accentuated acceleration cue reversal and hydraulic turn-around bump in the motion systems, conditions subjectively unacceptable to pilots. Adjustments necessary to reduce the 350 msec delay with the first software

Key Number

also resulted in unacceptable concomitant platform reactions.) To synchronize more nearly the visual and motion cues, the CIG transport delay compensation could be eliminated. "However, pilots preferred to have the visual system delay minimized as much as possible, especially for formation flying . . . Compensation for the majority of the CIG system transport delay turned out to be essential for proper simulation of formation flight." Nevertheless, with computer capabilities now coming into being, time delays and cue correlation problems can be minimized by using motion software iteration rates at least as high as that of the fastest flight module.

6 AUTHOR'S CONCLUSIONS:

"Simulator iteration rates in the future should not be based solely on the criteria of flight model stability but also on minimizing computational delays so that better simulator cue coordination can be achieved . . . (However) iteration rate manifested delays are only part of the total motion system delay problem. For platform motion systems to be used as effective motion cueing devices for the very responsive fighter-trainer-type aircraft simulators, their hardware and drive algorithm response time will have to be improved significantly."

7 EVALUATION:

Through process by process analysis of time requirements, the authors showed clearly that visual and platform motion cues could be more closely correlated, but at the expense of either delaying visual cues or introducing undesirable platform effects. The former was as undesirable as the latter, at least for some flight tasks. It was not clear in the report, however, whether or not delayed visual cues (and possibly instrument responses) might lead to more satisfactory conditions for some flight tasks. There is another consideration that could result in the motion-visual cue correlation issue becoming moot: Empirical studies of the value of platform motion, at least for many aspects of flight training, as often as not have shown no beneficial effects of motion. Hence, while inconsistent visual-motion cues might be disturbing, the disturbance (if any) could be removed when motion can be eliminated altogether. For tasks requiring motion, however, the analyses and conclusions given in this report should be considered.

14 DEPENDENT VARIABLES:

Computer image generation (CIG), platform motion cue correlation

Key Number

22 SYSTEM/CLASS:
Advanced Simulator for Undergraduate Pilot Training; computer image generator

24 NUMBER OF PAGES:
0006

26 NUMBER OF REFERENCES:
0002

28 RESEARCH CLASS:
Logical Study

29 RESEARCH METHOD:
Deductive reasoning

33 SUPPLEMENTARY NOTES:
Presented as Paper 76-005 at the AIAA Visual and Motion Simulation Conference, Dayton, Ohio, April 26-28, 1976.

36 REPORT TITLE:
Time-Delay Problems Encountered in Integrating the Advanced Simulator for Undergraduate Pilot Training

37 REPORT AUTHOR:
Gum, D.R.; Albery, W.B.

38 REPORT DATE:
77/04/00

40 ORIGINATING ACTIVITY:
Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio

52 PUBLISHER/SPONSOR:
American Institute of Aeronautics and Astronautics, Inc., New York, N.Y.

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 087
24 August 1979

Key Number
1 ACCESSION NUMBER:

4 CITATION:
Zavalova, N.D.; Ponomarenko, V.A. Characteristics of Flier's Behavior Under Complicated Flight Conditions. National Technical Information Service, Springfield, Virginia, JPRS 52233, January, 1971.

5 ABSTRACT:
PURPOSE: The purpose of the experiment was to identify characteristics of pilot's behavior in a flight emergency in order to determine requirements for teaching appropriate emergency reactions.
METHOD: Ss included 17 test pilots and 20 pilots from line units. Eight Ss were, and 29 were not, aware of the nature of the experiment. During a single flight for each S, the experimenter (E), a pilot himself, inconspicuously actuated an autopilot malfunction on 5-7 occasions. As a result, the two-seater trainer rotated about its longitudinal axis at an angular velocity of 70 degrees/second. Changes in speed, banking, and altitude were recorded, as were reaction times to manipulate controls and turn off the autopilot, and rate of heartbeat and respiration.
RESULTS: All Ss responded correctly to the controls on all trials and in essentially the same amount of time (approximately .27 sec). Altitude was maintained in 95 per cent of the trials, and only for one trial did altitude change by 500 meters. Changes in banking were less than 50 degrees in 95 per cent of the trials, and changes in velocity never exceeded 20km/hour. More than 20 seconds expired before the autopilot was switched off in 40 per cent of the trials, and more than 60 seconds in 15 per cent. Rates of heartbeat and respiration were higher for the Ss than for E, and decreased for Ss over trials. These rate differences and changes were interpreted as indicating emotion rather than physical displacement as the cause for Ss' heartbeat and respiratory reactions. The 29 naive Ss were divided into 3 groups based on their times in switching off the autopilot. The quickest group (6 Ss) had immediately reported to E tne cause of the emergency, and during post-flight questioning in interviews and by questionnaires they reported that they knew immediately that the autopilot was at fault, and thus reacted without having to think. The second quickest group (20 Ss), while not disconcerted during the emergency, paused to analyze rationally what had

Key Number

occurred--Did the E do it? Is it a genuine malfunction? Some queried E before switching off the autopilot, some considered various possible control difficulties first, and some apparently deduced straightforwardly that the autopilot was at fault from the nature of the emergency. A third group (3 Ss) were simply bewildered--"the signal received was transformed into clear-cut, definite information on'y with difficulty, after erroneous trials. One of them did not determine the cause of banking until after the fourth malfunction." The problem for training was seen as providing the instruction necessary to make all pilots respond as the quickest group did, i.e., to make appropriate actions to emergencies automatic, unthinking, and immediate. To do so, the pilot must be trained so as to minimize emotional reactions which are disruptive and which inhibit activity, sometimes completely. The improvement over trials of Ss' reaction times in switching off the autopilot, and the fact that even the most bewildered Ss began to acquire "concrete signal value" from the emergency, suggested that experience with unexpected malfunctions should be provided often during training.

7 EVALUATION:

Perhaps the most striking aspect of the findings of this study was that many experienced pilots were slow in identifying the cause of the emergency. Even a test pilot, who by the nature of his occupation was supposedly prepared for all kinds of emergencies, "kept pressing futilely for 59 sec on a button, although he knew he had to push a switch." Thus, as the authors insisted, a systematic program during training to habitualize fault identification and proper reactions to emergencies is indicated. The purported specific physiological mechanisms that supposedly must be trained (e.g., an "action receptor" to automatize reactions) snould not be the focus, however. References to hypothesized physiological mechanisms are common in Russian psychological literature, as they were in American periodicals through the 1940s. As became evident, learning principles are more applicable to behavioral change when they are stated in empirically-based behavioral terms. Hence, the abstract above omitted references to such mechanisms, but did use the author's behavioral concepts.

8 COMMENTS:

This report appeared originally in the Russian periodical, VOPROSY PSIKHOLOGII, No. 5, 1970.

Key Number

14 DEPENDENT VARIABLES:
Maintenance of bank, airspeed, and altitude; control-manipulative reaction time; time to correct fault; rate of heartbeat; rate of respiration

15 INDEPENDENT VARIABLES:
Inserted autopilot malfunction

16 MEASUREMENT/STATISTICAL METHODS:
t test

23 SUBJECT POOL:
Test pilots; line pilots

24 NUMBER OF PAGES:
0014

25 NUMBER OF REFERENCES:
0009

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Informal experiment

36 REPORT TITLE:
Characteristics of Flier's Behavior Under Complicated Flight Conditions

37 REPORT AUTHOR:
Zavalova, N.D.; Ponomarenko, V.A.

38 REPORT DATE:
71/01/25

48 REPORT NUMBER:
JPRS 52233

52 PUBLISHER/SPONSOR:
National Technical Information Service, Springfield, Virginia

56 TYPE OF PUBLICATION:
Journal article

64 LOCATION SYMBOL:

<u>Key Number</u>

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 088
25 August 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Ontiveros, R.J. Capabilities, Necessary Characteristics and Effectiveness of Pilot Ground Trainers, Phase 2: Visual Reference Flight Maneuvers. Department of Transportation, Washington, D.C., Report No. FAA-RD-73-108, August, 1973.

5 ABSTRACT:
PURPOSE: The purpose of the study was to establish guidelines for the development of standards of acceptability, especially as they applied to visual simulation, of pilot ground trainers used for primary flight training.
METHOD: Prior to the experiment, certain aircraft flight characteristics were documented during a single flight test in a Cherokee 180 flown by a test pilot. Selected maneuvers were performed, and external scenes and the aircraft's instrument readings were recorded on video tape. In addition, a series of pre-solo maneuvers were executed and similarly documented. These maneuvers were: (1) taxi; (2) take-off; (3) straight and level flight; (4) medium, (5) shallow, and (6) steep bank turns; (7) climb; (8) descent; (9) climbing, and (10) descending turns; (11) slow flight; (12) power-off, and (13) power-on stalls; (14) flap usage; (15) slip/skid; (16) crosswind tracking; (17) rectangular pattern; (18) airport traffic pattern; (19) S turn; (20) final approach; (21) landing; and (22) landing rollout. Seventeen of these maneuvers were used in the experiment, while (1), (2), (20), (21), and (22) were eliminated, primarily because the visual system to be used could not simulate visual closure or closure rate. A fixed-base ground trainer representative of a single-engine general aviation aircraft was used during training. It was equipped with elevator, elevator trim tab, flap, aileron, and rudder controls. A film strip projector presented colored sky-earth scenes on a veritcal white screen located above the trainer's instrument panel. The scenes were correlated with flight control and power inputs, and represented simulated visual cues associated with pitch, roll, and yaw. Visual effects during left and right turning were simulated through 360 degrees. An airplane-shaped position light, also projected onto the screen, responded to trainer airspeed and heading changes. Ten flight naive Ss were instructed in each of the 17 maneuvers in the trainer. Each daily session consisted of a 10-minute preflight briefing, 45 minutes of

Key Number

trainer practice, and a 15-minute postflight debriefing. A given maneuver had to be performed at criterion level (within 100 ft of altitude, 10 degees of heading, and 5 knots airspeed) before beginning another maneuver, and all previously learned maneuvers were reviewed at the start of each trainer session. Total times in the trainer to reach criterion on all maneuvers varied from 6.1 to 10.3 hours, with a mean of 8.4 hours. Finally, each S was given up to three trials at performing each of the maneuvers in a Cherokee 180. No instruction was given during those trials.

RESULTS: Maneuvers, and mean number of Cherokee trials, for which all Ss attained criterion were: (3), 1.5; (4), 1.8; (7), 1.4; (8), 1.4; (10), 1.3; (12), 1.8; (16), 1.1; and (17), 1.8. Nine of the 10 Ss attained criterion of (5), (9), (13), and (18), with mean trials of 2.2, 2.0, 1.4, and 1.7, respectively. No S reached criterion on (6) or (15), only three on (11) and (19), and only four on (14). Following the presentation of results, a synopsis of each maneuver was given, together with simulator controls and instruments needed, descriptions of the visual and flight characteristics, and desirable visual-flight responses to control inputs.

6 AUTHOR'S CONCLUSIONS:

Positive transfer from ground trainer to aircraft flights can be achieved with simulated visual external horizontal and directional referents for pitch, roll, and yaw, provided there are "functional" rudder, aileron, elevator, and elevator turn controls, a throttle, and "minimum instrumentation" of airspeed, altimeter, heading information, and tachometer. Visual changes must correlate with flight controls, and have a "minimum" lag. "A constant pressure control system is acceptable provided it affects attitude correctly. Most critical is elevator control with a good system interconnect of elevator trim control . . ." Fixed-based trainers cannot adequately alert a pilot for control of slip-skid. Torque effects are needed with power or altitude changes. "A vertical visual display system is equally as effective as the real world horizontal ground plane for training subjects in ground reference maneuvers such as crosswind tracking, rectangular and airport traffic patterns." While the visual system used was not effective for the S-turn maneuver, it did help in teaching procedural aspects of the S turn. Maneuvers (1), (2), (20), (21), and (22) above require a complex visual system with at least two-axis capability to display variable closure rate, changing perspective of ground geometry, and crosswind effect.

7 EVALUATION:

The efficacy of a relatively unsophisticated visual system for teaching flight naive Ss transferable visual flight rules

Key Number

control in a simulator was demonstrated, provided it can be assumed that the Ss used only, or primarily, visual cues in the simulator and Cherokee. In the absence of a control group trained in the simulator without extracockpit visual cues, this assumption may well be questioned. At any rate, the experiment was well prepared and conducted, and the considerable effort that went into the analyses of minimum trainer requirements for the various maneuvers produced a useful set of guides for determining needed simulator capabilities.

14 DEPENDENT VARIABLES:
Performance of primary training maneuvers; straight/level flight; medium, shallow, and steep bank turns; climb; descent; climbing and descending turns; crosswind tracking; slow flight; power-on and power-off stalls; flap usage; slip/skid; rectangular and airport traffic patterns; S turns

15 INDEPENDENT VARIABLES:
Simulated visual scenes during training

22 SYSTEM/CLASS:
Fixed-base flight simulator with film-strip visual system

23 SUBJECT POOL:
Flight naive persons of varied ages and backgrounds

24 NUMBER OF PAGES:
0048

25 NUMBER OF REFERENCES:
0016

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Informal experiment

36 REPORT TITLE:
Capabilities, Necessary Characteristics and Effectiveness of Pilot Ground Traincrs, Phase 2: Visual Reference Flight Maneuvers

37 REPORT AUTHOR:
Ontiveros, R.J.

38 REPORT DATE:
73/08/00

Key Number

40 ORIGINATING ACTIVITY:
National Aviation Facilities Experimental Center, Federal Aviation Administration, Atlantic City, New Jersey

44 CONTRACT/PROJECT/TASK:
184-531-030

48 REPORT NUMBER:
FAA-RD-73-108

49 OTHER REPORT NUMBER:
FAA-NA-73-15

52 PUBLISHER/SPONSOR:
Department of Transportation, Washington, D.C.

56 TYPE OF PUBLICATION:
Technical report

60 DISTRIBUTION STATEMENT:
Unlimited

64 LOCATION SYMBOL:

65 LOCATION FILE:

66 LAST DATE OF UPDATE:

ABSTRACT 089
15 September 1978

Key Number

1 ACCESSION NUMBER:

4 CITATION:
Puig, J.A.; Gill, S. Evaluation of an Automated Flight Training System: Ground Control Approach Module. Naval Training Equipment Center, Orlando, Florida, NAVTRAEQUIPCEN IH-264, February, 1976.

5 ABSTRACT:
PURPOSE: This study was designed to evaluate the training effectiveness of an adaptive ground control approach (GCA) module.
METHOD: Thirty-six Ss who had recently completed basic jet training were assigned to two matched groups of 18 Ss each. The experimental group (E) was trained using an automated GCS module which provided automatic syllabus control and a simulated GCA controller. For the control group (C), an instructor entered the conditions for each GCA and acted as the GCA controller. The training course was comprised of seven types (not identified) of GCAs, arranged in order of increasing difficulty. Both normal and minimum fuel approaches were used. All Ss were trained to proficiency in Device 2F90, then transferred to a TA-4J aircraft. In the 2F90, instructors rated the performance of each S on glideslope, course, speed, and overall performance. Photographs were made of CRT (cathode ray tube) displays of flight path, and computer printouts provided measures of accuracy of glide path, course, and angle of attack. Various scores obtained in TA-4J GCAs were combined in an unexplained manner to yield total scores for approaches identified only as PAR (precision approach radar), ASR (airport surveillance radar), CSF (compass system failure), MF (minimum fuel), PP (partial panel), and PP and CSF combined. Signed rank tests for paired replicates were run for all but the combined PP/CSF measures.
RESULTS: No significance was obtained for ASR, CSF, or PP approaches. E scores were higher (p. = .01) of PAR, and C scores were higher (p. = .01) for MF approaches. Only five E Ss and four C Ss could reach the PP/CSF level during the time available for the study. An independent t test revealed no significant difference for these subgroups. (No values were given for any test, only for significant ps.)

6 AUTHOR'S CONCLUSIONS:
"The feasibility of using the (adaptive) GCA module with an operational flight trainer . . . has been demonstrated."

Key Number

7 EVALUATION:
No issue is taken here with the authors' conclusion regarding feasibility. However, the incomplete reporting of the study leaves questions regarding the equivalent effectiveness of automated and manual GCA training control. The structure of the criterion scores, the crucial dependent variables, is unknown. It is not even clear how the training procedures were implemented. Also, an objection can be raised regarding the use of a t test for independent samples to compare subgroups of Ss from matched E and C groups. The original 18 E Ss had an average basic flight grade, the matching variable, of 3.066, while the mean grade was 3.064 for the 18 C Ss. Whether or not the Ss who completed PP/CSF were among the better of both groups, restrictions were imposed on sampling variabilities. Thus, the t obtained was lower than it would have been with an appropriate test.

14 DEPENDENT VARIABLES:
Total scores of unspecified structure on GCA performance

15 INDEPENDENT VARIABLES:
Automated adaptive vs. manual GCA simulator training

16 MEASUREMENT/STATISTICAL METHODS:
Signed rank test for paired replications; t test

22 SYSTEM/CLASS:
Flight simulator/2F90

23 SUBJECT POOL:
Recent graduates of a basic jet training course

24 NUMBER OF PAGES:
0066

25 NUMBER OF REFERENCES:
0004

28 RESEARCH CLASS:
Experimental Analysis

29 RESEARCH METHOD:
Formal experiment/single variable

32 DESCRIPTIVE NOTES:
Final report

36 REPORT TITLE:
Evaluation of an Automated Flight Training System: Ground Control Approach Module

Key Number

37 REPORT AUTHOR:
Puig, J.A.; Gill, S.

38 REPORT DATE:
76/02/00

40 ORIGINATING ACTIVITY:
Human Factors Laboratory, Naval Training Equipment Center, Orlando, Florida

44 CONTRACT/PROJECT/TASK:
NAVTRAEQUIPCEN Task No. 4751-03

48 REPORT NUMBER:
NAVTRAEQUIPCEN IH-264

52 PUBLISHER/SPONSOR:
Naval Training Equipment Center, Orlando, Florida

56 TYPE OF PUBLICATION:
Technical report

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Unlimited

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